CLASS 117, SINGLE-CRYSTAL, ORIENTED-CRYSTAL, AND EPITAXY GROWTH PROCESSES; NON-COATING APPARATUS THEREFOR

SECTION I - CLASS DEFINITION

(A) GENERAL STATEMENT

(1) Note. Terms having an asterisk (*) are defined in the GLOSSARY, below.

This is the generic class for:

(a) processes consisting of the single or repeated unit operation of forming a single-crystal* of any type of material, including inorganic or organic;

(b) such processes combined with perfecting operations; and

(c) apparatus for conducting non-coating processes of this class.

However, the following classes specifically provide for the unit operation of single-crystal* growth:

Class 505, Class 419; Class 204; and Class 164, subclass 122.2.

And the following classes specifically provide for apparatus for single-crystal* growth:

Class 118; Class 204; and Class 422.

B. GUIDE TO USING THIS CLASS DEFINITION

The statements in LINES WITH OTHER CLASSES, below, set forth the precise and controlling class lines.

Unless otherwise indicated, placement according to these class lines is subject to the hierarchical and comprehensive rules of placement.

Class 117 is most broadly organized according to processes and apparatus. Further arrangement is premised on the physical state of the immediate-precursor* (the precursor* material immediately adjacent to the growing single-crystal*).

The descending order of arrangement of the physical state of the immediate-precursor* is: solid or gel state; liquid or supercritical state; vapor or gaseous state. Care must be exercised to correctly identify the physical state of the immediate-precursor* in order to obtain correct placement.

For example, vapor phase deposition of a non-single-crystal* material followed by a single-crystal* forming step from that vapor deposited material would be placed as follows: into a solid state precursor* subclass if that formation step does not change the solid state of the material (such as by melting or liquefying it); into a liquid state precursor* subclass if the material is liquified in the formation step and the single-crystal* is grown from the liquid; into a vapor state precursor* subclass if during the single-crystal* formation step the material is evaporated or sublimed and redeposited to form a single-crystal*.

This class also provides an extensive Cross-Reference Art Collection schedule. A portion of this is loosely based upon the European Patent Office-modified IPC classification. However, where there are indents, the U.S. hierarchical practice of placement in the first appropriate subclass among corresponding indents is followed. Coextensive use of cross-referencing has been used so that this alternative schedule may provide an acceptable substitute search in certain situations. However, it is important to note that where the standard U.S. subclasses have substantially complete overlap within a Cross-Reference Art Collection subclass, cross-referencing from that U.S. subclass into the Cross-Reference Art Collection subclass has not been done, and a note appears in each of those subclasses indicating that cross-referencing is unnecessarily duplicative and that a complete search of the Cross-Reference Art Collection concept would have to include the noted U.S. subclass. For example, a U.S. patent cross-referenced into subclass 75 would not be placed into the cross-reference art collection 921, as the notes therein indicate.

SECTION II - NOTES TO THE CLASS DEFINITION

(1) NOTE. DEFINITION OF SINGLE-CRYSTAL*.

The definition of single-crystal* for this class is set forth below in the Glossary below.

Twins*, oriented-crystals*, and superlattices* are included in this class because they are similar or identical to the more conventionally categorized epitaxy* and single-crystals*. Further, such materials are frequently used as though they are single-crystals*. The use of the term single-

crystal* throughout this class will be taken to encompass twin*, superlattice*, epitaxy*, oriented-crystal*, or single-crystal*.
Both twins* and superlattices* are considered to be composed of layers of single-crystals* and therefore are classified where layered single-crystals* are provided for in the schedule.

(2) NOTE. KEYWORDS.
References directed to the following are deemed proper for Class 117 unless the disclosure reveals that the product is not single-crystal*:
crystal or seed pulling;
Verneuil method;
whisker growth;
superlattice*;
twin*;
oriented-crystal*;
epitaxy*; or
epitaxial* deposition or growth.

(3) NOTE. INDICATIVE TERMINOLOGY.
The following criteria are intended to assist in the determination of whether placement is proper in this class.
(a) Positive indications include:
the use of one or more of the terms monolithic crystal, single crystal, isotropic crystal, monocrystal, or macro-crystal;
method or apparatus which produces a true single crystal; i.e., only one crystal;
method or apparatus which produces multiple single-crystals* simultaneously by virtue of multiple, purposeful seed crystals; and the reference clearly focuses on the utility of a single-crystal* (e.g., optical or electrical device comprising one crystal, or a gemstone).
Class 117 is not the proper place for uncontrolled crystallization. When processing conditions may be controlled with an intent to encourage growth of a larger size crystal, this does not rise to the level of single-crystal* growth or apparatus for Class 117 if recovery involves merely selecting product crystals which are merely fortuitously large enough from the other product crystals. The following may be considered as indicating (but necessarily determining) that placement does not belong in Class 117.
(b) Negative indications include:
spontaneously nucleated crystallization; i.e., without seed crystal;
crystallization which results in an indefinite number of crystals and/or in an indefinite distribution of crystal sizes;
crystallization for the stated purpose of recovery and/or purification of the material, particularly when an intended use doesn't depend upon a single-crystal* property; e.g., crystallization of salt or sugar to achieve purification or recovery;
the use of the term bulk crystals or polycrystalline; and
the reference focuses on bulk uses; e.g., abrasives.
NB: The term bulk crystal is used in some technologies to mean single-crystal* while the term bulk crystals is used in some technologies to mean numerous purified crystals, usually from material recovery operations.

(4) NOTE. PERFECTING OPERATIONS COMBINED WITH GROWTH.
This class provides for single-crystal* growth and apparatus combined with perfecting operations and means, unless such combination is specifically provided for elsewhere.
Perfecting operations are as defined herein or are operations which are merely broadly or nominally claimed so as not to be a basis for classification in an art class.
Special class lines affecting placement of single-crystal* growth combined with perfecting steps exist with the metallurgy arts (Class 148 and Class 164), and with the semiconductor art of Class 438, as noted herein below. As a result of these special class lines, certain operations combined with single-crystal* growing which are otherwise perfecting for this class are provided for and placed outside of Class 117 (i.e., if the single-crystal* is a non-semiconductor metal* or is a Class 438-type semiconductor).
Determination of whether a step or operation is perfecting focuses on its contribution to the forming of the single-crystal* product and on the single-crystal* product itself. Operations are categorized hereinbelow as (a) simultaneous, (b) prior, or (c) subsequent.
(a) Simultaneous.

Simultaneous operations are those performed on the growing single-crystal*. All simultaneous operations performed upon the growing single-crystal* are considered perfecting and hence processes including simultaneous operations are located in this class. For example: doping the growing crystal while growing; plasma-enhanced CVD*; volatile constituent overpressure; growing while shaping (e.g., confined in a recess); etc.

However, Class 164 provides for processes and apparatus forming a non-semiconductor metal* single crystal in a mold.

(b) Prior.

Prior operations which are preparatory to the growth operation are perfecting. Preparatory operations may be enhancing of or necessary to the growth.

Examples of perfecting prior steps are: pretreatment or manipulation of a substrate* or seed* such as cleaning, polishing, shaping, etching, ablating, doping, diffusing, gettering, ion implanting, aligning, or positioning; preparation or manipulation of a precursor* such as (a) mixing together components of a liquid, or (b) deposition of other than single-crystal* material which is then subsequently grown to single-crystal* (e.g., amorphous material deposited) or subsequently recrystallized to single-crystal* (e.g., polycrystalline material deposited), or (c) working, shaping, and/or heat treating a solid precursor* which is subsequently grown to single-crystal* (e.g., in the solid phase); preparation, pretreatment, or manipulation of a base* if such is necessary to successful growth (e.g., to create the necessary substrate* for epitaxy*); pretreating a substrate* or seed* by preparing a non-seeding mask (e.g., patterning) directly on a substrate* or seed* (this may include several steps, such as coating followed by selective etching); pretreating a substrate* or seed* by etching a region thereof (e.g., making a groove); combinations of perfecting steps.

Examples of claimed prior steps proper for Class 438 when combined with single-crystal* growth are: nonuniform material removal of a substrate* or base* in order to impart Class 438-type semiconductor device structure or region (i.e., other than to uniformly clean or "polish" the substrate) to a subsequently formed single-crystal* (e.g., etching or ablating to form a recess, groove, rib, mesa, ridge, strip, stripe, terrace, trench, trough, etc., see U.S. Patent No. 4,383,883), except that removal of non-seed material (e.g., a mask) in order to expose a seed* material (i.e., to expose a substrate*) followed by material deposition and single-crystal* growth seeded by the exposed substrate* is placed in Class 117 (e.g., epitaxial* layer overgrowth); acting to alter the composition of a substrate* or a non-seed material so as to provide a Class 438-type semiconductor device structure or region, even if performed uniformly or even if such is also necessary to prepare the substrate* to achieve the subsequent crystal growth (e.g., doping by ion implanting, diffusing or fusing, gettering); broad or nominal claimed step of forming a Class 438-type semiconductor device region or structure in a substrate*. Note, repeatedly growing single-crystal* on single-crystal* is a Class 117 process.

(c) Subsequent.

Subsequent operations are perfecting usually only if they do not modify the physical shape or the single-crystallinity of the grown single-crystal*.

Growth combined with subsequent shaping operations are usually beyond perfecting and are usually proper for classes providing for combination operations such as Class 29, Class 438, Class 264, and Class 156.

Subsequent steps which are considered perfecting are typically recovery steps or the operation recited merely broadly or nominally so as not to afford a basis of classification in an art class. In addition, heat treatment and impurity content modifying (e.g., doping or implanting or diffusing or gettering) are designated perfecting operations in this class.

Examples of perfecting subsequent operations are: cleaning; removing "flashing" (the unintentional or extraneous material); washing; drying; removing a substrate* or a base*; removing a mask; separating from a substrate* or a base*; removing from a reaction vessel; uniformly etching or grinding (e.g., polishing or cleaning); impurity content modifying (e.g., doping, implanting, diffusing, gettering); and heat treating (e.g., annealing, tempering).

Examples of subsequent operations which are beyond perfecting when combined with single crystal growth are: nonuniform material removal (such as etching or ablating) to provide structure in the single-crystal* (e.g., groove, rib, mesa, ridge, strip, stripe, terrace, recess, trench, trough); coating with other than single-crystal* material; bombardment to produce an induced nuclear reaction or transmutation (see Class 376, subclasses 156+).

Examples of claimed subsequent perfecting operations proper for Class 438 when acting upon or forming a Class 438-type semiconductor device and when combined with single-crystal* growth are: nonuniform material removal of a substrate or non-seed base in order to impact structure to a previously formed single crystal component of the semiconductor substrate, such structure intended to permit the utilization of the electrical characteristics of the semiconductive regions thereof (e.g., etching or ablating to form a recess, groove, rib, mesa, ridge, strip, stripe, terrace, trench, trough, see U.S. Patent No. 4,383,883); composition modifying, whether uniformly or otherwise (e.g., doping, gettering); heat treatment (except merely a specified cooling schedule, which is proper for Class 117, subclass 3); and a broad or nominally recited step of forming a Class 438-type semiconductor electrical device or device structure or device region.

Class 148 provides for single-crystal* growing when combined with a subsequent heat treatment (which herein includes controlled cooling) step when the purpose of the heat treatment (or controlled cooling) is to modify the internal physical structure or chemical property of a metal, alloy, or intermetallic material. Examples of claimed sebsequent operations proper for Class 148 even when combined with single-crystal* growth are solutionizing, homogenizing, and precipitation hardening.

(5) NOTE. CHEMICAL AND PHYSICAL REACTIONS.

Class 117 provides for single-crystal* growth and apparatus without regard to whether such growth and apparatus involves a chemical reaction* or a physical reaction or any combination thereof.

(6) NOTE. ZONE MELTING (E.G., ZMR*).

Processes and apparatus directed to moving zone melting or zone melt refining or zone leveling are assumed not to result in a single-crystal*, absent a recitation that a single-crystal* is formed.

However, where it is clear by disclosure that the usefulness of the intended product of the claimed process or apparatus relies upon a single-crystal* property (e.g., semiconductor for electronic devices), then it is appropriate to infer that the product is a single-crystal* even in the absence of an explicit statement.

(7) NOTE. SINGLE-CRYSTAL* MATRIX MATERIALS; NON-HOMOGENEOUS, NON-ISOTROPIC, OR IMPURE SINGLE-CRYSTALS*.

Class 117 takes processes and apparatus for making a single-crystal* having an impurity or foreign component therein so long as the single-crystal* forms a continuous matrix.

Examples of materials found within single-crystals* are: (a) electronic property affecting impurity (e.g., semiconductor dopant*); (b) optical property affecting component (e.g., solid needle crystals of titanium (IV) oxide within beryl matrix); and (c) a processing remnant such as a processing aide (e.g., graphite string used in string-stabilized web crystal).

(8) NOTE. TREATMENT OF SINGLE-CRYSTALS*.

Single-crystal* treatment, not combined with a step of growing a single-crystal*, is not provided for in Class 117.

Per se doping is proper for (a) Class 427 or (b) either Class 252 or Class 501 if a non-significant coating step makes a composition or (c) Class 438, if therein provided for.

Per se heat treatment of Class 438-type semiconductor material, including single-crystal* material, is provided for in Class 438. (However, note that application of heat to a polycrystalline or amorphous material to grow a single-crystal* is proper for Class 117.)

Per se heat treatment of non-semiconductor metal* to modify or maintain the internal

physical structure (e.g., microstructure) or chemical properties of non-semiconductor metal* is proper for Class 148. Note, however, that solid phase single-crystal* growing (i.e., heat treatment to recrystallize) of all materials, including the non-semiconductor metals*, is proper for Class 117.

Per se heat treatment of non-semiconductor, non-metal*, preformed, shaped, or solid article for the purpose of modifying or controlling the chemical or physical properties or characteristics of the article is proper for Class 264, subclasses 345+.

A. NOTES APPLICABLE ONLY TO PROCESSES OF THIS CLASS

(1) Note. VARIOUSLY CLASSIFIED NON-COATING PROCESSES.

A reference directed to process(es) which forms a single-crystal* species and which forms any one or combination of the species of an amorphous material or a polycrystalline material or multiple (non-single-crystal*) crystals (a) is proper for placement of the original where the most comprehensive embodiment is proper and (b) where there are equally comprehensive claims, is proper for placement of the original in Class 117, if single-crystal* embodiment is in any claim, singly or listed, or if only generic claims are presented and single-crystal* embodiment is disclosed.

(2) Note. Variously Classified Coating Operations.

A reference directed to coating process(es) which forms a single-crystal* coating species and which forms either or both of the species of an amorphous coating or a polycrystalline coating (a) is proper for placement of the original where the most comprehensive embodiment is proper and (b) where there are equally comprehensive claims, is classified using a genus-species rule as follows. A reference with coating process(es) which forms a single-crystal* coating as the solely claimed or disclosed species is proper for placement of the original in Class 117. A reference with generic claim(s) and plural claimed species or plural disclosed species is proper for placement of the original to Class 427 or Class 438, as appropriate.

B. NOTES APPLICABLE ONLY TO APPARATUS OF THIS CLASS

(1) Note. Coating Versus Non-Coating Apparatus.

Single-crystal* growth requires layering deposition of molecule upon molecule. However, in the case of apparatus for single-crystal* growth, a distinction is made between that used for a method of coating and that used for a method of non-coating.

Where the grown material is intended to mimic the shape of the substrate* or base*, then the grown material is a coating (often the substrate* or base* remains as a significant or integral part of the product in use), and the apparatus effective therefor is classified in Class 118, Class 204, or Class 422.

On the other hand, when the material deposition occurs so as to produce a product substantially independent of or far removed of the initial substrate* or base*, then the process is non-coating single-crystal* growth (often the substrate* or base* is not significant to or an integral part of the product in use), and the apparatus effective therefor is classified in Class 117.

Generally, Class 118 takes the apparatus for epitaxial* single-crystal* growth, while Class 117 takes most other single-crystal* growing apparatus.

(2) Note. Subcombination Apparatus.

Subcombinations having specific applications are placed with that specific application unless there is an art class providing for it.

(3) Note. Apparatus With Multiple Uses.

A reference having equally comprehensive claims to apparatus for multiple uses, or multiply disclosed uses and only generic claims (for example for making single-crystal* material or for making polycrystal material), is properly placed in Class 117 for the original and is cross-referenced to the other appropriate apparatus class for the other embodiments.

Further lines with other classes are found in References To Other Classes, below. They are identified as (1) Lines With Process Classes; (2) Lines with Article, Material, Composition, Device, And Product Classes; (3) Lines With Apparatus Classes

SECTION III - LINES WITH OTHER CLASSES AND WITHIN THIS CLASS

A. LINES WITH PROCESS CLASSES

See notes associated with processes in the Notes to the Class Definition section of this class. Also see process search references in References to Other Classes.

B. SELECTED NOTES TO ARTICLE, MATERIAL, COMPOSITION, DEVICE, AND PRODUCT CLASSES

Class 117 does not provide for the products of its processes or apparatus. The following is not represented as a complete listing of all possible locations for such products, but may be useful as a guide or starting point for locating them. See References to Other Classes, below.

C. LINES WITH APPARATUS CLASSES

See notes associated with apparatus in the Notes to the Class Definition section of this class. Also see apparatus search references in References to Other Classes.

SECTION IV - REFERENCES TO OTHER CLASSES

SEE OR SEARCH CLASS:

23, Chemistry: Physical Processes, for crystallization of inorganic compounds or non-metal* elements with no intent to obtain a single-crystal* product and having no significant shaping. Placement of the original, when both Class 117 and Class 23 species are claimed or where such are disclosed but only generic claims are present, is Class 117. Lines With Process Classes).

29, Metal Working, for processes which include diverse operations and which include a step of single-crystal* growth when making the specified articles enumerated in that part of the Class 29 schedule which precedes subclass 592, Processes of Mechanical Manufacture. Additionally, Class 29 takes processes which include diverse operations and which include a step of single-crystal* growth combined with (a) specific metal shaping steps or (b) mechanical joining either broad or specific. Class 117 takes multistep processes which include a step of single-crystal* growth combined with (a) broad or nominally claimed metal shaping steps or (b) assembling the precursors* of forming the single-crystal*. See subclasses 592.1+ for processes of mechanical manufacture of electrical devices not classified elsewhere. (Lines With Process Classes).

29, Metal Working, takes apparatus which practice diverse operations and which include a means of single-crystal* growth when making the specified articles enumerated in that part of the Class 29 schedule which precedes subclass 592, Processes of Mechanical Manufacture. For example, see subclass 25.35 for apparatus for manufacturing piezoelectric crystal devices by means comprising single-crystal* forming and additional manufacturing means. Additionally, Class 29 takes apparatus which practice diverse operations and which include a means of single-crystal* growth combined with (a) specific metal shaping means or (b) mechanical joining means either broad or specific. Class 117 takes apparatus which include a means of single-crystal* growth combined with (a) broad or nominally claimed metal shaping means or (b) means for assembling the precursors* of forming the single-crystal*. (Lines With Apparatus Classes.)

34, Drying and Gas or Vapor Contact With Solids, appropriate subclasses for cooling, treating, and drying processes not in combination with single-crystal* formation; e.g., solidification of bulk material. For further elucidation of what Class 34 takes, see (2) Note therein. Class 117 takes drying and gas or vapor contact of single-crystal* as a perfecting operation; i.e., combined with single-crystal* growth. (Lines With Process Classes).

34, Drying and Gas or Vapor Contact With Solids, for cooling, treating, or drying apparatus, not combined with single-crystal* forming means. See Class 34 definition for comprehensive statement of its relationship with other classes. (Lines With Apparatus Classes.)

62, Refrigeration, appropriate subclasses for processes of other than single-crystal* growing which include a Class 62 cooling step. (Lines With Process Classes).

62, Refrigeration, for apparatus for removing heat from a substance which may cause crystallization and not combined with single-crystal* forming means. (Lines With Apparatus Classes.)

63, Jewelry, subclass 32 for a gem or a stone intended to be worn by a person as an ornament. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

65, Glass Manufacturing, for processes of making glass. Fused quartz is considered glass. (A., Lines With Process Classes).

65, Glass Manufacturing, for glass making apparatus, especially subclasses 187+ and 193+, for means for pulling glass from a melt. (C., Lines With Apparatus Classes.)

75, Specialized Metallurgical Processes, Compositions for Use Therein, Consolidated Metal Powder Compositions, and Loose Metal Particulate Mixtures, subclass 10.11 for zone melting or refining and for fractional crystallization of metals or alloys wherein no single-crystal* is produced. If both single-crystal* and polycrystal formation are claimed, or both are disclosed but only generic claims are present, the original is proper for Class 117. See subclasses 331+ for forming metal powders from a melt or liquid without a shaping surface; e.g., liquid comminuting. (A., Lines With Process Classes).

118, Coating Apparatus, for apparatus for applying or obtaining a coating on a substrate (e.g., epitaxy*) and for apparatus not provided for elsewhere for treating the substrate (or base or work) or to subsequently treat the coating. See especially subclasses 400+ for liquid phase epitaxy* and subclasses 715+ for vapor phase epitaxy*. Apparatus for the non-coating (e.g., non-epitaxy*) single-crystal* growth is proper for Class 117. (C., Lines With Apparatus Classes.)

122, Liquid Heaters and Vaporizers, for apparatus for heating liquids which have a closed liquid heating chamber of generally disclosed utility and not combined with single-crystal* forming means. (C., Lines With Apparatus Classes.)

125, Stone Working, for processes of acting upon stone and stone-like material previously removed from its native position in the earth. (A., Lines With Process Classes).

126, Stoves and Furnaces, for apparatus for heating liquids which have an open liquid heating chamber of generally disclosed utility and not combined with single-crystal* forming means. (C., Lines With Apparatus Classes.)

127, Sugar, Starch, and Carbohydrates, appropriate subclasses for processes of recovery or treatment of class named materials which are not single-crystal*. (A., Lines With Process Classes).

127, Sugar, Starch, and Carbohydrates, appropriate subclasses for products of the processes of recovery or treatment of class named materials. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

127, Sugar, Starch, and Carbohydrates, subclasses 15+ and 17+ for apparatus for bulk crystallizing and treatment of bulk crystals of the class-defined materials. (C., Lines With Apparatus Classes.)

134, Cleaning and Liquid Contact With Solids, for apparatus for cleaning and for miscellaneous contact of liquids with solids in general, including such with single-crystal*, and not combined with single-crystal* forming means. (C., Lines With Apparatus Classes.)

136, Batteries: Thermoelectric and Photoelectric, subclasses 200+ for thermoelectric devices, subclasses 203+ for Peltier* thermoelectric effect devices, and subclasses 243+ for solar cell devices. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

148, Metal Treatment, appropriate subclasses for (a) the class provided for per se processes of non-semiconductor metal* treating or (b) single-crystal* growth of metal, alloy, or intermetallic material combined with a subsequent step of heat treatment (which herein includes controlled cooling) when the purpose of the heat treatment (or controlled cooling) is to modify the internal physical structure or chemical property of a metal, alloy, or intermetallic material. When the subsequent heat treatment (or controlled cooling) merely operates on the single-crystallinity, such as stress or strain annealing or to remove point defects, the combined process is proper for Class 117; when the subsequent heat treatment (or controlled cooling) operates to effect significant metal, alloy, or intermetallic heat treatment (or controlled cooling) purposes, such as solutionizing, homogenizing, or precipitation hardening, then the combined process is proper for Class 148. Class 117 provides for simultaneous or prior perfecting operations combined wiht single-crystal growing. See Notes to the Class Definition in Class 117 for discussion of perfecting operations. (A., Lines With Process Classes)

148, Metal Treatment, subclasses 33+ for p/n junction semiconductor stock material (including superlattice materials), subclasses 400+ for metal* stock material, and subclass 404 for directionally solidified metal* stock mate-

rial.(B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

159, Concentrating Evaporators, subclasses 47.1+ for processes of crystallization without significant chemical changes and in which single-crystal* growth is not intended. (A., Lines With Process Classes).

159, Concentrating Evaporators, subclass 33 and subclass 45 for concentrating evaporators with means for collecting (bulk) crystals. (C., Lines With Apparatus Classes.)

164, Metal Founding, subclasses 122.1+ for simultaneously shaping (i.e., in a mold) and solidifying to form non-semiconductor metal* directionally solidified material or single-crystal*. See subclasses 48+, 250.1+, and 469 and Digest 5 for the use of high energy radiation to melt a metal* when not combined with growing a single-crystal*. (A., Lines With Process Classes).

164, Metal Founding, appropriate subclasses for apparatus for dynamic metal* molding or for treating of metal* in a mold, including apparatus which grows metal* single-crystal*. (C., Lines With Apparatus Classes.)

165, Heat Exchange, for apparatus for heating and cooling the same material, including single-crystal*, when not combined with single-crystal* forming means. (C., Lines With Apparatus Classes.)

196, Mineral Oils: Apparatus, subclass 14.5 for dewaxing apparatus of mineral oils by solidification or crystallization. (C., Lines With Apparatus Classes.)

203, Distillation: Processes, Separatory, subclass 48 for processes of distillation combined with crystallization (bulk). (A., Lines With Process Classes).

204, Chemistry: Electric and Wave Energy, for processes of forming a single crystal by a method set forth in that class definition as restricted in the Class 204 class definition, (5) Note, and the Class 204, subclass 157.15, (9) Note. Thus, Class 204 is proper for single-crystal* growth processes which involve a stated chemical reaction and glow discharge, plasma torch, electrolysis, electrophoresis, sputtering, or vacuum arc discharge. (A., Lines With Process Classes).

204, Chemistry: Electrical and Wave Energy, for apparatus for forming single crystal by a Class 204 method which involves a stated chemical reaction, but with exceptions noted in the class definition at (C) and in (5) Note; see Class 204, subclass 157.15, (9) Note. (C., Lines With Apparatus Classes.)

210, Liquid Purification or Separation, appropriate subclasses for processes which include crystallization, other than single-crystal* growth, when such is a by-product of a process which occurs simultaneously with a Class 210-defined process which is the primary purpose. (A., Lines With Process Classes).

210, Liquid Purification or Separation, for apparatus in which recovery of a crystallized material is a by-product of a Class 210-defined process which is the primary purpose. Since placement is according to disclosed intent, appropriate cross-referencing is usually required. (C., Lines With Apparatus Classes.)

219, Electric Heating, for processes using high energy radiation to melt, absent the growing of a single-crystal*. (A., Lines With Process Classes).

219, Electric Heating, for electrical heating devices of generally disclosed utility and not combined with single-crystal* forming means. (C., Lines With Apparatus Classes.)

226, Advancing Material of Indeterminate Length, appropriate subclasses for processes of handling single crystals of indeterminate length (e.g., fiber) and not combined with single-crystal* forming means. (A., Lines With Process Classes).

226, Advancing Material of Indeterminate Length, appropriate subclasses for apparatus for handling single crystals of indeterminate length (e.g., fiber) and not combined with single-crystal* forming means. (C., Lines With Apparatus Classes.)

249, Static Molds, appropriate subclasses for static mold of fluent material not combined with a diverse art device such as single-crystal* forming means. (C., Lines With Apparatus Classes.)

252, Compositions, appropriate subclasses for processes of making compositions of the class, unless by a process provided for elsewhere. See subclasses 62.3+ for processes of making a composition suitable for a barrier layer device (e.g., by doping without a claimed step of crystal growing); subclasses 500+ for making electrically conductive or emissive compositions; subclasses 582+ for making non-linear optical compositions; subclasses 301.16+, 301.36, or 301.4+ for making coherent light generating

compositions; and subclasses 299.01+ for making liquid crystal compositions. (A., Lines With Process Classes).

252, Compositions, for class provided for compositions, which may be single-crystal*, especially: subclasses 62.3+ for barrier layer device compositions such as p-type and n-type semiconductor materials; subclass 62.9 for piezoelectric compositions; subclasses 301.16+, 301.36, and 301.4+ for light emitting compositions (e.g., fluorescent, phosphorescent, or coherent (laser)); subclasses 500+ for electrically conductive or emissive compositions; subclasses 582+ for non-linear optical compositions; and subclasses 299.01+ for liquid crystal compositions. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

257, Active Solid-State Devices (e.g., Transistors, Solid-State Diodes), for semiconductor devices such as diodes, transistors, and thyristors. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

264, Plastic and Nonmetallic Article Shaping or Treating: Processes, for per se processes of shaping or treating non-glass, non-metal* single-crystal*, except as provided for in Class 437, and for processes of single-crystal* forming of non-semiconductor, non-metal* material combined with a step proper for Class 264 and which is not a Class 117 perfecting step (see Notes to the Class Definition in Class 117 for perfecting operations). See subclasses 5+ for forming non-glass, non-metal* powders from a melt or liquid without a shaping surface; e.g., liquid comminuting. Class 117 takes (a) single-crystal* growing simultaneous with shaping (except molding of non-semiconductor metal* which is placed in Class 164, subclasses 122.1+) or (b) single-crystal* forming of all types of materials, including organic or inorganic (non-metal* or metal*), combined with a broad or nominally recited shaping or treating step. See subclasses 340+ for the per se treating of a preformed, shaped, or solid article, which may be a single-crystal*, wherein the chemical or physical property or characteristic is modified or controlled, and see subclasses 345+ thereunder where such treatment is heat treating the article. (A., Lines With Process Classes).

266, Metallurgical Apparatus, appropriate subclasses for apparatus for refining, purifying, or otherwise treating molten or liquified metal* or for melting metal*, not provided for elsewhere.

269, Work Holders, e.g., subclass 46, for workholders not provided for in other art classes. Class 117 takes its own workholders. (C., Lines With Apparatus Classes.)

310, Electrical Generator or Motor Structure, subclasses 311+ for an inorganic piezoelectric structure when shaped to claimed configuration, where the configuration is disclosed as being significant to the piezoelectric property of the material (e.g., plate). (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

356, Optics: Measuring and Testing, subclasses 30+ for processes of optical measuring or testing of a crystal or a gem. (A., Lines With Process Classes).

356, Optics: Measuring and Testing, subclasses 30+ for apparatus for optical measuring or testing of crystal or gem. (C., Lines With Apparatus Classes.)

359, Optical: Systems and Elements, for optical elements and optical systems not elsewhere classified. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

366, Agitating, appropriate subclasses for agitating apparatus not intended for chemical reaction and not combined with single-crystal* forming means. (C., Lines With Apparatus Classes.)

372, Coherent Light Generators, appropriate subclasses for art named devices (e.g., lasers), especially subclasses 43.01+ for semiconductor lasers. (B., Selected Notes to Article, Material, Composition, Device, and Product Classes.)

373, Industrial Electric Heating Furnaces, appropriate subclasses for apparatus having a specific electrical heating structure and of generally disclosed utility and for heating a material, especially subclass 17 for apparatus for zone melting by electron beam furnace and subclass 139 for apparatus for zone melting by induction heating. Class 117 takes apparatus claimed or solely disclosed for single-crystal* growing. (C., Lines With Apparatus Classes.)

376, Induced Nuclear Reactions: Processes, Systems, and Elements, especially subclasses 156+, for processes, either per se or combined with single-crystal* growing, of acting on a single-crystal* which involves bombardment (e.g., irradiation, to produce an induced nuclear reaction or transformation), especially subclass

183 for doping a semiconductor material. (A., Lines With Process Classes).

376, Induced Nuclear Reactions: Processes, Systems, and Elements, appropriate subclasses for apparatus for carrying out nuclear reactions which may act on a single-crystal*; e.g., irradiation to perform nuclear transformation (e.g., doping of a semiconductor material). (C., Lines With Apparatus Classes.)

385, Optical Waveguides, for passive optical elements effecting a deviation of light rays or a modification in the character or properties of the light, especially subclasses 129+ for planar optical waveguides. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

419, Powder Metallurgy Processes, for processes of forming single-crystals* by Class 419 methods.

420, Alloys or Metallic Compositions, for methods of making metals and metallic compositions, other than single-crystal*. (A., Lines With Process Classes).

420, Alloys or Metallic Compositions, for metal*, alloy, or intermetallic compositions which may be single-crystal*. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

422, Chemical Apparatus and Process Disinfecting, Deodorizing, Preserving, or Sterilizing, subclasses 129+ for apparatus for crystallizing material other than single-crystal*, not provided for elsewhere, and in which chemical reaction(s) is (are) provided for; subclasses 186+ for apparatus for forming single-crystal* by a method of Class 204, subclasses 157.15+; subclasses 245.1+ for apparatus for crystallizing material other than single-crystal*, not provided for elsewhere, in which only physical process(es) is (are) provided for; and in all cases such apparatus not intended for acting upon glass or metal*, or for shaping an article. (C., Lines With Apparatus Classes.)

423, Chemistry of Inorganic Compounds, for processes of producing or separating by a chemical reaction an inorganic compound or nonmetal* element, which may have crystalline form, and where there is no intent to obtain a single-crystal* product. Note, although Class 117 is proper for original placement of single-crystal* diamond making, a mandatory search is found in Class 423, subclass 446 which is the locus for all diamond making and products (unless a coating), whether or not a chemical reaction is involved. (A., Lines With Process Classes).

423, Chemistry of Inorganic Compounds, for inorganic compounds or nonmetal* elements, single-crystal* or otherwise, especially where shape, structure, or device is not claimed. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

425, Plastic Article or Earthenware Shaping or Treating: Apparatus, subclasses 6+ for apparatus making non-glass, non-metal* powders, which may be crystals, from liquid by means dividing or comminuting and allowing the liquid to solidify while in particulate form of a desired size or shape but with no shaping surface; subclass 77 for ultra-high-pressure generating apparatus other than for single-crystal* forming; subclass 222 for tumbling type agglomerating apparatus; and appropriate subclasses for dynamic molding apparatus for other than glass.

427, Coating Processes, appropriate subclasses for processes of depositing a coating other than single-crystal* (e.g., polycrystalline or amorphous) on a substrate, except as specifically provided for elsewhere. (A., Lines With Process Classes).

428, Stock Material or Miscellaneous Articles, for structurally defined non-metal* single-crystal* products, and for non-structurally defined laminates comprising a single-crystal*, particularly subclasses 544+ for a metal* stock having contiguous metal* layers (e.g., where one or more layers may be single-crystal*). (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

430, Radiation Imagery Chemistry: Process, Composition, or Product Thereof, for processes which include a single-crystal* growth step combined with a non-perfecting (see Notes to the Class Definition in Class 117 for perfecting operations) operation which is proper for this class. (A., Lines With Process Classes).

432, Heating, appropriate subclasses for apparatus of general utility for the generation of heat and its application to materials, not provided for elsewhere. (C., Lines With Apparatus Classes.)

438, Semiconductor Device Manufacturing: Process, appropriate subclasses for (a) per se treatments or operations acting on single-crystal* semiconductor material (e.g., heat treating, doping, etching, coating, etc.) not specifically provided for elsewhere or (b) growing a single-

crystal* semiconductor material (i.e., a Class 117 step) combined with named diverse treatments or operations, including those noted in Notes to the Class Definition in Class 117 for perfecting operations. Where there are only generic claims and both Class 438 and Class 117 processes are disclosed, or where both Class 438 and Class 117 processes are claimed and the claims are equally comprehensive, the reference is originally placed in Class 438 and cross-referenced to Class 117. (A., Lines With Process Classes).

501, Compositions: Ceramic, for processes of making ceramic compositions not provided for in an art class and when there is no intention of growing single-crystal* ceramics. (A., Lines With Process Classes).

501, Compositions: Ceramic, for compositions of ceramic materials, especially subclass 86, for synthetic single-crystal* ceramic composition of gem quality. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

505, Superconductor Technology: Apparatus, Material, Process, for all subject matter relating to high temperature (functioning above 30 degrees K) superconductor compositions, materials, devices, and methods of making same. See subclass 451 for zone melting or seed pulling processes which make superconductor precursors or products and see cross-reference art collection 729 for producing high temperature superconducting single crystal or single crystal film or single crystal layer. (A., Lines With Process Classes).

505, Superconductor Technology: Apparatus, Material, Process, for all subject matter relating to high temperature (functioning above 30 degrees K) superconductor compositions, materials, devices, and methods of making same, see subclass 451 for processes of making superconducting precursor or product by zone melting or seed pulling and cross-reference art collection 729 for making high temperature superconducting single crystal or single crystal film or single crystal layer. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

520, -528, Synthetic Resins or Natural Rubbers -- Part of the Class 520 Series, for processes of making materials of the class definition which are other than single-crystal*. (A., Lines With Process Classes).

520, -528, Synthetic Resins or Natural Rubbers -- Part of the Class 520 Series, for materials of the class definition which may be single crystal. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

530, Chemistry: Natural Resins or Derivatives; Peptides or Proteins; Lignins or Reaction Products Thereof, for processes of making materials of the class definition which are other than single-crystal*. (A., Lines With Process Classes).

530, Chemistry: Natural Resins or Derivatives; Peptides or Proteins; Lignins or Reaction Products Thereof, for materials of the class definition which may be single crystal. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

532, -570, Organic Compounds -- Part of the Class 532-570 Series, for processes of synthesizing organic compounds which are other than single-crystal*. (A., Lines With Process Classes).

532, -570, Organic Compounds -- Part of the Class 532-570 Series, for materials of the class definition which may be single crystal. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

585, Chemistry of Hydrocarbon Compounds, for processes of making materials of the class definition which are other than single-crystal*. See subclasses 812+ for processes of purification, separation, or recovery of hydrocarbons by crystallization, other than single-crystal* forming. (A., Lines With Process Classes).

585, Chemistry of Hydrocarbon Compounds, for materials of the class definition which may be single crystal. (B., Selected Notes To Article, Material, Composition, Device, And Product Classes.)

SECTION V - GLOSSARY

AMORPHOUS

Noncrystalline; having no molecular lattice structure; e.g., glass, liquid.

BASE

The surface upon which a coating is formed, except where a surface has been previously coated and a second coating is applied, in which case the initial surface is the base. Contrast with substrate*.

BERYL

Beryllium aluminum silicate; $Be_3Al_2Si_6O_{18}$; $3BeO{\cdot}Al_2O_3{\cdot}6SiO_2$; emerald; aquamarine. Usually green.

BOULE

(From French; ball) A lump of material. In this class the term applies to the raw, single-crystal* product.

CBE

Chemical Beam Epitaxy*.

CHALCEDONY

Microcrystalline form of quartz; usually milky or grayish in color.

CHEMICAL REACTION

For purposes of Class 117, chemical reaction is given a broad meaning. The following are included: metathesis; changing the water of hydration; forming intermetallic compounds from constituent elements or from alloys; forming compound semiconductor material from constituent elements; forming ions (ionization) or ionized plasma. Not included are: dissolution of a compound and solidification (e.g. crystallization) of the same compound; a change of phase (e.g., amorphous to single-crystal*); change of crystal phase or form (e.g., face centered cubic to body centered cubic).

CHRYSOBERYL

Beryllium aluminate; $BeO{\cdot}Al_2O_3$; cat's eye; alexandrite; optionally with up to about 10 wt% chromium oxide and titanium oxide.

CORUNDUM

Natural aluminum oxide; Al_2O_3; sometimes with intended small amounts of cobalt (green), chromium (red; i.e., ruby), iron (yellow), magnesium, or silica; synthetic emery.

CRUCIBLE

A vessel for containing a molten material. The crucible may be of the same material as the molten material and may ultimately become molten.

CRYPTOCRYSTALLINE

Microscopic crystalline structure, indistinguishable to the naked eye.

CRYSTAL BOUNDARY

The interface between a crystal and its surroundings; e.g., another crystal, air.

CSL

Coherent Superlattice.

CTSL

Coherent Tilted Superlattice.

CVD

Chemical Vapor Deposition. CVD may be employed to produce single-crystal*, polycrystal, or amorphous material. See also MOCVD.

CZ

Abbreviation for Czochralski. J. Czochralski was the Polish inventor of the basic single crystal pulling method (1918) bearing his name.

DIASPORE

$Al_2O_3{\cdot}H_2O$; a natural hydrous aluminum oxide; $HAlO_2$.

DOPANT

A desired material intentionally present in an amount insufficient to satisfy the lattice unit cell, which may be present interstitially or by occupying crystal lattice positions substitutionally.

DOPING

The process of introducing a dopant* into a material.

EDFFG

Edge-Defined Film-Fed Growth. Also abbreviated as EDFG and EFG.

EPITAXY

Formation of a single-crystal* on a substrate* (which acts as a seed*) or the product of such a process. Usually, the formed crystal bears a definite crystallos:graphic relationship to the substrate*. Typically, the term applies to coating or layer formation when the width and length are substantially larger than the height and when the substrate* remains as a significant or integral part of the product in use.

FERRITE SPINELS

MFe_2O_4, where M = divalent metal (or mixtures thereof) and having the cubic lattice structure.

FET

Field Effect Transistor.

GARNET, SYNTHETIC

Term applied to crystals having the same complicated cubic structure as mineral garnets or beryl, but usually without the silicon; e.g., yttrium-iron, $Y_3Fe_5O_{12}$. Other variations include substituting part of the yttrium and/or iron with valence-equivalent metals.

GETTERING

A process or operation that reduces or removes impurities or defects from a region either by complete removal (e.g., volatilization) or by transporting them to another region.

GGG

Gadolinium Gallium Garnet. Composite oxide compound $Gd_3Ga_5O_{12}$. Useful as substrate in magnetic bubble domain memory and as man-made gemstones.

IMMEDIATE-PRECURSOR

The precursor immediately next to the growing single-crystal* and from which the single-crystal* forms or grows. Contrast with precursor*.

JUNCTION, SEMICONDUCTOR

The region of transition between semiconduction regions of different electrical properties, usually between p-type and n-type materials, and usually a junction exhibits asymmetric conductivity.

LATTICE CONSTANT

Usually the edge length of a unit cell.

LEC

Liquid Encapsulated Czochralski (CZ*) method.

MBE

Molecular Beam Epitaxy*.

METAL

Element other than non-metal* (see non-metal*).

METAL, NON-SEMICONDUCTOR

See NON-SEMICONDUCTOR METAL.

MOCVD

Metal-Organic CVD*. CVD in which a precursor* contains an organo-metallic compound. Also sometimes OMCVD.

MOMBE

Metal-Organic Molecular Beam Epitaxy*. MBE in which a precursor* contains an organo-metallic compound.

MOS FET

Metal Oxide Semiconductor Field Effect Transistor.

NON-METAL

The twenty-one elements: hydrogen, boron, carbon, silicon, nitrogen, phosphorus, oxygen, sulfur, selenium, tellurium, fluorine, chlorine, bromine, iodine, astatine, helium, neon, argon, krypton, xenon, and radon.

NON-SEMICONDUCTOR METAL

A metal* other than which has a disclosed semiconductor property or intended use. For example, a single-crystal* of germanium or indium antimonide would be inferred to be a semiconductor even though composed of a metal* because of its known semiconductor property.

NUTRIENT

The source material from which the single-crystal* deposits or grows. See also precursor*.

ORIENTED-CRYSTAL

A material in which substantially all the crystal grains are oriented in a preferential way. Also called preferred-orientation polycrystalline material.

OMCVD

Metal-Organic CVD*.

PECVD

Plasma Enhanced CVD*.

PELTIER EFFECT

A thermoelectric effect wherein electric current between/through a solid/solid or a solid/liquid junction creates heating in one side and cooling in the other.

P/N JUNCTION

An interface formed by two semiconductor materials in which one contains a charge carrier which is an electron donor (n-type semiconductor) and the other contains a charge carrier which is an electron acceptor (p-type semiconductor).

PRECURSOR

Any part, or all, of the starting material from which a single-crystal* is grown. This may be a material which undergoes one or more chemical reactions* prior to the actual crystal growth step. Hence, the term is not limited to the compound or composition present just immediately prior to the growth of the single-crystal*. Contrast with immediate-precursor*. See also nutrient*.

QUARTZ

SiO_2; silicon dioxide; silica. Polycrystalline forms include agate, cat's eye, chalcedony, and jasper. Crystalline forms include amethyst, catalinite, citrine, rose quartz, and smoky quartz.

QUARTZ, FUSED

Vitreous or glassy quartz.

ROCHELLE SALT

Potassium sodium tartrate; $KNaTartrate{\cdot}4H_2O$; ($KNaCO_2CHOHCHOHCO_2{\cdot}4H_2O$); ($KNaC_4H_4O_6{\cdot}4H_2O$). Seignette's salt.

SCHOTTKY JUNCTION

An interface formed by a semiconductor and a conductor.

SEED

A material, usually a single-crystal*, upon which a single-crystal* is grown. Seeded crystal growth proceeds by the alignment of atoms or molecules or clusters into a thermodynamically favored arrangement determined by the nature of the seed.

SEIGNETTE'S SALT

See Rochelle salt.

SEMICONDUCTOR DEVICE

Used here to mean any article or structure comprised of semiconductor material, such as the optical waveguides of Class 385 or the electronic semiconductor devices of Class 438. The phrase is not determinative of proper classification; intended use frequently dictates proper classification.

SEMICONDUCTOR JUNCTION

See JUNCTION, SEMICONDUCTOR.

SINGLE-CRYSTAL

Solid phase material characterized by an absence of crystal boundaries and by a uniform atomic structural arrangement. However, in this class, the term includes material composed of twins*, superlattice*, epitaxy*, oriented-crystals*, or enlarged crystals (when the enlarged crystals are used as though they are a single-crystal or when the enlarged crystals are used individually as single-crystals).

SOI

Semiconductor On Insulator. A layered structure commonly found as the starting point for integrated circuit manufacture on silicon wafers.

SOS

Silicon On Sapphire.

SPINEL

MAl_2O_4; rubicelle, ruby almandine, ruby balas. Also sometimes used generically to refer to a crystal having the cubic crystal lattice form.

SUBSTRATE

The surface upon which a coating is formed. In the case of single-crystal* growth, such as epitaxy*, the substrate is also a seed*. Contrast with base*.

SUPERLATTICE

A single-crystal*, usually composed of a semiconductor, having an internal structure of more than two layers, each layer having a composition different from the next adjacent layer. The term includes alternating layers of two compositions.

TWIN

(Twin plane) A polycrystalline material in which the adjoining lattices have a mirror-image symmetrical relationship.

VERNEUIL

A. Verneuil, French inventor of the crystal growth technique (1902) used for materials with a high melting point. The Verneuil method is typified by use of a high temperature heat source, such as a gas flame or plasma torch, into which powdered material is directed, whereupon it melts as or prior to its arrival to a thin film of melt on a seed crystal which is pulled away at an appropriate rate.

VFG

Vertical Freeze Gradient. Also VGF.

VPE

Vapor Phase Epitaxy*.

WHISKER

A single-crystal* which is typically small diameter, elongate, and generally cylindrical.

YAG

Yttrium Aluminum Garnet.

ZMR

Zone Melt Recrystallization.

SUBCLASSES

1 PROCESSES JOINING INDEPENDENT CRYSTALS:

This subclass is indented under the class definition. Processes in which two or more independently manipulatable single-crystals* are joined in a specified crystallographic orientation so as to form a single-crystal*.

(1) Note. This subclass is not the proper location for epitaxy* layer overgrowth types of processes since crystals joined in that process originated on a common substrate and hence were not independently manipulatable, such processes will be found below in this class.

SEE OR SEARCH THIS CLASS, SUBCLASS:

4+, for de-twinning processes.

45, for epitaxy* layer overgrowth processes in which a moving solid-liquid-solid region is used.

54+, for liquid phase epitaxy* growth processes.

84+, for vapor phase growth processes such as vapor phase epitaxy*.

SEE OR SEARCH CLASS:

228, Metal Fusion Bonding, particularly subclass 121 for bonding of nonmetals with a metal filler.

438, Semiconductor Device Manufacturing: Process, subclasses 455+ for bonding of plural semiconductor substrates.

2 PROCESSES OF GROWTH WITH A SUBSEQUENT STEP ACTING ON THE CRYSTAL TO ADJUST THE IMPURITY

AMOUNT (E.G., DIFFUSING, DOPING, GETTERING, IMPLANTING):
This subclass is indented under the class definition. Subject matter in which, subsequent to a claimed single-crystal* growing step, the crystal is treated to remove or add an impurity; e.g., by a diffusion, doping*, gettering*, or implanting process.

SEE OR SEARCH THIS CLASS, SUBCLASS:
3, for like processes in which the impurity is merely redistributed rather than adjusted.

SEE OR SEARCH CLASS:
427, Coating Processes, for the per se step, other than as specifically provided for elsewhere (see the reference to Class 438 below).
438, Semiconductor Device Manufacturing: Process, for such processes in which a single crystal of semiconductor material is acted upon and for the per se operation of gettering*, doping*, implanting*, or diffusion acting on the semiconductor material.

3 PROCESSES OF GROWTH WITH A SUBSEQUENT STEP OF HEAT TREATING OR DELIBERATE CONTROLLED COOLING OF THE SINGLE-CRYSTAL:
This subclass is indented under the class definition. Subject matter in which the process includes a step subsequent to a claimed single-crystal* growth which includes: (a) the application of heat to the single-crystal* or (b) a specified, deliberate cooling schedule (i.e., the specification of a cooling rate or step, or of one or more temperature plateaus prior to or during cooling down to room temperature).

(1) Note. A specified temperature gradient in the cooling crystal is included here.

(2) Note. The positive recitation of a subsequent step of holding the single-crystal* at a specified temperature, or of cooling at a specified rate, constitutes a heat treatment for placement here. The mere recitation of "heat treatment" or "tempering" or "annealing" or other like terms is not enough for placement in this subclass; such mere recitations will find proper placement in the appropriate crystal growing subclasses, below, based upon the claimed growth step.

(3) Note. A single-crystal* growth step followed by heat treatment to de-twin is proper for placement here.

(4) Note. See the Search Class entries for Class 148 and Class 437 listed below for exceptions.

SEE OR SEARCH THIS CLASS, SUBCLASS:
4+, for processes of crystal formation from the solid state and for per se processes of de-twinning.
11+, for processes which act on single-crystal* and which result in the liquefying thereof and from which a single-crystal* is then grown.
204, for corresponding apparatus other than coating apparatus.

SEE OR SEARCH CLASS:
148, Metal Treatment, appropriate subclasses for (a) the class provided for per se processes of non-semiconductor metal* treating or (b) single-crystal* growth of metal, alloy, or intermetallic material combined with a subsequent step of heat treatment (which herein includes controlled cooling) when the purpose of the heat treatment (or controlled cooling) is to modify the internal physical structure or chemical property of a metal, alloy, or intermetallic material. When the subsequent heat treatment (or controlled cooling) merely operates on the single-crystallinity, such as stress or strain annealing or to remove point defects, the combined process is proper for Class 117; when the subsequent heat treatment (or controlled cooling) operates to effect significant metal, alloy, or intermetallic heat treatment (or controlled cooling) purposes, such as solutionizing, homogenizing, or precipitation hardening, then the combined process is proper for Class 148. Class 117 provides for simultaneous or prior perfecting operations combined with single-crystal*

growing. See Class 117 definition, section C, (4) Note, for discussion of perfecting operations.

264, Plastic and Nonmetallic Article Shaping or Treating: Processes, subclasses 345+ for, per se, processes of heat treating a non-semiconductor, non-metal*, preformed, shaped, or solid article which may be a single-crystal*.

438, Semiconductor Device Manufacturing: Process, appropriate subclasses for (a) per se treatments or operations acting on single-crystal* semiconductor material (e.g., heat treating, doping, etching, coating, etc.) not specifically provided for elsewhere or (b) growing a single-crystal* semiconductor material (i.e., a Class 117 step) combined with named diverse treatments or operations, including those noted in the Class 117 definition, section I, C, (4) Note. Where there are only generic claims and both Class 438 and Class 117 processes are disclosed, or where both Class 438 and Class 117 processes are claimed and the claims are equally comprehensive, the reference is originally placed in Class 438 and cross-referenced to Class 117.

4 PROCESSES OF GROWTH FROM SOLID OR GEL STATE (E.G., SOLID PHASE RECRYSTALLIZATION):

This subclass is indented under the class definition. Subject matter which includes a step forming single-crystal* from an immediate-precursor* in solid or gel state.

(1) Note. This definition does not include processes in which the solid or gel passes through another state other than a gel or solid immediately prior to crystal formation. Thus, the dissolving of a solid nutrient* into a liquid would be considered passing through another state and placement would be proper in Class 117, subclasses 11+, even though some solid state nutrient* may be constantly supplying precursor to the dissolving vehicle during the crystal formation (e.g., in a spatially separated nutrient* zone).

(2) Note. Per se heat treating to de-twin involves the elimination of crystal boundary while in the solid state and hence is placed here.

SEE OR SEARCH THIS CLASS, SUBCLASS:

200+, for corresponding apparatus, other than coating apparatus.

5 Organic product:

This subclass is indented under subclass 4. Subject matter in which the product formed is a single-crystal* of an organic compound, as defined in Class 532.

6 At pressure above 1 atmosphere:

This subclass is indented under subclass 4. Subject matter in which the process includes use of pressure greater than 1 atmosphere during the growth step.

7 Using heat (e.g., strain annealing):

This subclass is indented under subclass 4. Subject matter in which the process includes use of heat to initiate and/or maintain crystal growth.

SEE OR SEARCH THIS CLASS, SUBCLASS:

3, for processes growing a single-crystal* which include a subsequent step of heat treating the product.

SEE OR SEARCH CLASS:

264, Plastic and Nonmetallic Article Shaping or Treating: Processes, subclasses 345+ for, per se, processes of heat treating a non-semiconductor, non-metal*, preformed, shaped, or solid article, which may be a single-crystal*.

8 Of amorphous precursor:

This subclass is indented under subclass 7. Subject matter where the immediate-precursor* which is being thermally treated is amorphous* (non-crystalline).

9 Epitaxy formation:

This subclass is indented under subclass 7. Subject matter in which the single-crystal* grown is epitaxy*.

10 Using temperature gradient (e.g., moving zone recrystallization):
This subclass is indented under subclass 7. Subject matter in which a temperature gradient is used to effect the crystal growth.

11 PROCESSES OF GROWTH FROM LIQUID OR SUPERCRITICAL STATE:
This subclass is indented under the class definition. Subject matter in which an immediate-precursor* supplies crystallization material in the liquid or supercritical state to the growing single-crystal*.

(1) Note. The immediate-precursor* may comprise dissolved, molten, or otherwise liquid media.

(2) Note. All uses of the term liquid in this and indented subclasses shall be taken to mean liquid or supercritical state.

(3) Note. See the (5) Note located in subclass 13 for discussion of distinguishing characteristics among several liquid phase processes.

SEE OR SEARCH THIS CLASS, SUBCLASS:
206+, for corresponding apparatus other than coating apparatus.

12 Crucibleless process having movement of discrete droplets or solid particles to thin-film precursor (e.g., Verneuil method):
This subclass is indented under subclass 11. Subject matter in which droplets or solid particles of precursor* are moved as such (i.e., as discrete particles) to the thin-film liquid precursor* zone or region from which the single-crystal* product is grown and which precusor is not contained by a crucible.

SEE OR SEARCH THIS CLASS, SUBCLASS:
207, for corresponding apparatus.

13 Having pulling during growth (e.g., Czochralski method, zone drawing):
This subclass is indented under subclass 11. Subject matter characterized by bringing a seed* into contact with a liquid precursor* (or nutrient*) media to initiate and conduct the growth process by then withdrawing it under conditions which permit crystal formation while pulling.

(1) Note. The salient feature of this and indented subclasses is the necessary and sufficient requirement of relative movement between the crystal product (holder) and the nutrient* supply holder (or means).

(2) Note. Processes termed zone drawing or zone pulling in which a zone of melted material is moved through a solid precursor* while simultaneously conducting a drawing or pulling operation and wherein the drawing or pulling causes the product to have a cross-sectional mass different from the solid precursor* are properly placed in this subclass and its indents. This subclass also includes those processes in which a product has a larger diameter than the precursor*. These might be termed “pushing” techniques as opposed to pulling techniques. For example see U.S. Patent No. 3,622,282.

(3) Note. Although a crucible* with a reservoir of nutrient* is typical of these processes, this is not a requirement.

(4) Note. This subclass and its indents do not include processes in which crystal pulling is used only to initiate the crystallization. For example, pulling initially and then switching to moving zone process is proper for subclasses 37+.

(5) Note. The moving zone, Bridgman-Stockbarger, and crystal pulling methods each involve a moving solid-liquid interface with a trailing recrystallization. The following typical indicia are provided to help in distinguishing them from each other.

(a) Moving zone recrystallization:

Two solid-liquid interfaces are present and are generally planar and generally parallel to each other.

Both precursor* and product are attached to and moved by the same means or are controlled so as to move so that there is no relative movement between them, or both precursor* and product are attached to the same structure and the heating means is moved, but again there is no relative movement between precursor* and product.

The precursor* may be a layer (e.g., a coating) or may be sandwiched between two layers.

In the case of crucibleless zone melting, there is no disparate-material crucible*.

Precursor* and product travel along a common axis and travel at the same rate, or the heating element moves while the precursor* and product remain stationary.

The heating element may be immersed in the liquid zone.

(b) Bridgman-Stockbarger method:

There is one solid-liquid interface.

The crystal grows into the nutrient*.

There is a vessel which contains the liquified precursor* and the crystal product.

(c) Crystal pulling:

A seed* material is moved into contact with the precursor*, and then withdrawn so as to pull the precursor* from the liquid by surface tension into a cooler zone where single-crystallization* occurs.

There may be no replenishment of precursor* during the process, in which case there will be only one solid-liquid interface; e.g., the precursor* is completely liquefied and contained in a crucible*.

There may be another solid-liquid interface associated with liquefying of solid precursor* replenishment.

Direction of travel of the precursor* material (or precursor* replenishment material) and the product are unrelated to each other.

The seed* is attached to a pulling means/structure.

The crucible* may be composed of precursor* material and thus may be consumed.

(6) Note. The pulling of a body which results in a polycrystalline rod will generally be found in Class 23 if no chemical reaction occurs and Class 423 if a chemical reaction occurs. If shaping means are employed (e.g., EDFFG*), the polycrystallization process will generally be found in Class 264.

SEE OR SEARCH THIS CLASS, SUBCLASS:

12, for processes of growing wherein there is movement of discrete droplets or solid particles (e.g., Verneuil method).

37+, for processes of moving zone recrystallization without a pulling or drawing operation.

54+, for processes of immersing a substrate* or seed* and then withdrawing it, either to cause epitaxy* or after epitaxy* has occurred.

208+, for corresponding apparatus other than coating apparatus.

14 With a step of measuring, testing, or sensing (e.g., using TV, photo, or X-ray detector or weight changes):

This subclass is indented under subclass 13. Subject matter which includes the measuring, testing, or sensing of a process condition or parameter during the process.

(1) Note. Since all processes involve control of process parameters, placement here requires more than merely a statement of controlling or operating at a certain set of conditions. Thus, not included are mere recitations of "controlling" or "maintaining." Further, merely reciting a program or cycle or

time control is not sufficient for placement here.

(2) Note. Equivalent terms include examining, inspecting, observing, viewing, and monitoring.

15 With responsive control:
This subclass is indented under subclass 14. Subject matter further including a step of controlling a specified parameter or condition in response to the measured, tested, or sensed condition or parameter.

16 Shape defined by a solid member other than seed or product (e.g., edge-defined film-fed growth, Stepanov method):
This subclass is indented under subclass 15. Subject matter wherein a solid member (i.e., a physical or mechanical shaper or die) is provided sufficiently close to the precursor*-product interface to affect, and at least partially define, the shape of the crystal as it is pulled from the liquid and passes against the shaping means.

(1) Note. The solid member may be pulled with and become attached to or embedded in the crystal; e.g., string-stabilized web pulling.

SEE OR SEARCH THIS CLASS, SUBCLASS:
23, for similar processes which do not involve measuring, testing, or sensing.

17 With contact with an immiscible liquid (e.g., LEC):
This subclass is indented under subclass 13. Subject matter in which the liquid precursor* contacts another liquid, immiscible therewith, for any indicated purpose.

18 Using a sectioned crucible or providing replenishment of precursor:
This subclass is indented under subclass 17. Subject matter in which the liquid precursor* is present in a crucible* which has sections clearly defined by a physical member, at least two of which sections contain liquid precursor* (e.g., a sectioned crucible or a double crucible*), or in which a step of precursor* replenishment is recited.

SEE OR SEARCH THIS CLASS, SUBCLASS:
31, for processes using sectioned crucible* in the absence of an immiscible liquid.

19 Forming an intended mixture (excluding mixed crystal) (e.g., doped):
This subclass is indented under subclass 13. Subject matter wherein the process includes an intended or desired mixture in the single-crystal* product, but excluding mixed crystal compositions like $Ga_xAl_{1-x}As$.

(1) Note. Compounds and intermetallics, such as GaAs or InSb, are stoichiometric compounds and hence are not considered mixtures for purposes of placement here.

(2) Note. Unintended or undesirably impure single-crystals* are not considered intended mixtures for purposes of placement here.

SEE OR SEARCH THIS CLASS, SUBCLASS:
2, for processes of doping* subsequent to a single-crystal* growth step.

SEE OR SEARCH CLASS:
438, Semiconductor Device Manufacturing: Process, for a process consisting of the single crystal growth of a semiconductor material from the liquid phase which is combined with named operations or treatments, including those noted in the Class 117 definition, section I, C, Note (4).

20 Comprising a silicon crystal with oxygen containing impurity:
This subclass is indented under subclass 19. Subject matter in which the crystal product is silicon which includes an intended or desired impurity which contains or consists of oxygen.

21 Comprising a semiconductor with a charge carrier impurity:
This subclass is indented under subclass 19. Subject matter in which the crystal product is a semiconductor which includes an intended or desired impurity which is an electric charge carrier.

22 Forming adjoining crystals of different compositions (e.g., junction):
This subclass is indented under subclass 21. Subject matter in which adjoining single-crystals* of different composition are formed, either simultaneously or successively.

(1) Note. For placement in this subclass, a reference must claim a process in which both of the adjoining single-crystals* are grown in the claimed process.

23 Shape defined by a solid member other than seed or product (e.g., edge-defined film-fed growth, Stepanov method):
This subclass is indented under subclass 13. Subject matter wherein a solid member (i.e., a physical or mechanical shaper or die) is provided sufficiently close to the precursor*-product interface to affect, and at least partially define, the shape of the crystal as it is pulled from the liquid and passes against the shaping means.

(1) Note. The solid member may be pulled with and become attached to or embedded in the crystal; e.g., string-stabilized web pulling.

SEE OR SEARCH THIS CLASS, SUBCLASS:
54+, for processes of liquid epitaxy* crystallization even though the epitaxy* substrate may be pulled relative to the precursor*.

24 Embedded in product (e.g., string-stabilized web):
This subclass is indented under subclass 23. Subject matter in which the solid member becomes embedded in the crystal product; e.g., string-stabilized web growth.

25 Defines a product with a hollow structure (e.g., tube):
This subclass is indented under subclass 23. Subject matter in which the solid member controls the growth so as to define a single-crystal* product having a hollow structure.

(1) Note. Cross-referencing to art collection 920 is precluded as unnecessarily duplicative.

26 Defines a flat product:
This subclass is indented under subclass 23. Subject matter in which the solid member controls the growth so as to define a single-crystal* product having two substantially planar and parallel faces.

(1) Note. Cross-referencing to art collection 922 is precluded as unnecessarily duplicative.

27 Pulling includes a horizontal component:
This subclass is indented under subclass 26. Subject matter in which the pulling motion includes at least some horizontal component.

(1) Note. Cross-referencing to art collection 922 is precluded as unnecessarily duplicative.

28 Including non-coincident axes of rotation (e.g., relative eccentric):
This subclass is indented under subclass 13. Subject matter characterized in that non-coincident axes of rotation are employed during growth, for example, where the axes of rotation of the seed/product and of the liquid precursor* support means (e.g., the crucible*) are not coincident or where the seed/product is simultaneously spun and eccentrically rotated.

29 Passing non-induced electric current through a crystal-liquid interface (e.g., Peltier):
This subclass is indented under subclass 13. Subject matter in which the crystal and the liquid are connected to an electric potential and current is caused to flow therebetween.

(1) Note. RF induction, per se, is not proper for placement here.

SEE OR SEARCH CLASS:
204, Chemistry: Electrical and Wave Energy, for processes of forming a single crystal by a method set forth in that class definition and as restricted in Class 204, subclass 157.15, (9) Note. Thus, Class 204 is proper for single crystal growth processes which involve glow discharge, plasma torch, electrolysis, electrophoresis, sputtering, or vacuum arc discharge.

30 With liquid flow control or manipulation during growth (e.g., mixing, replenishing, magnetic levitation, stabilization, convection control, baffle):

This subclass is indented under subclass 13. Subject matter wherein flow of a liquid precursor* is purposefully manipulated or controlled during growth.

SEE OR SEARCH THIS CLASS, SUBCLASS:

15+, if the control is in response to a measured, tested, or sensed condition or parameter.

33, for processes wherein the manipulation or control comprises replenishing of the liquid precursor*.

31 Including a sectioned crucible (e.g., double crucible, baffle):

This subclass is indented under subclass 30. Subject matter in which the liquid precursor* is present in a crucible* which has sections clearly defined by a physical member, at least two of which sections contain liquid precursor*; e.g., double crucible*.

32 Using a magnetic field:

This subclass is indented under subclass 30. Subject matter wherein the process uses a magnetic field to act directly on the liquid to effect said flow control or manipulation.

(1) Note. Cross-referencing to art collection 917 is precluded as unnecessarily duplicative.

33 Replenishing of precursor during growth (e.g., continuous method, zone pulling):

This subclass is indented under subclass 30. Subject matter in which precursor* is replenished or added to the liquid precursor* while growth occurs.

(1) Note. Included here are processes in which the precursor* is added to the crucible* in any form (solid, liquid, or gas), including those arrangements in which a mass of precursor* residing in the crucible* from the inception of growth is liquefied while growth occurs, or those arrangements in which a moving zone is used; i.e., zone pulling.

(2) Note. Cross-referencing to art collection 912 is precluded as unnecessarily duplicative.

SEE OR SEARCH THIS CLASS, SUBCLASS:

31, for replenishment wherein a sectioned crucible* is utilized.

34 Including significant cooling or heating detail:

This subclass is indented under subclass 33. Subject matter in which the means or method of providing or controlling heating or cooling is significantly specified; i.e., it is more than merely recited or provided for.

35 With a significant technique for (a) preliminary preparation or growth starting or (b) product handling or growth ending (e.g., arrangement of or crystallography of seed):

This subclass is indented under subclass 13. Subject matter in which a significant technique (i.e., a technique more than merely recited or provided for) is specified for: preparing the precursor* materials or the apparatus; handling the product (e.g., severing product from seed holder, manipulatively removing from furnace); initiating growth; or terminating growth (e.g., accelerated pulling motion).

(1) Note. Placement herein requires more than merely mixing a precursor* starting batch.

36 Precursor intentionally contains an excess component or a non-product appearing component (e.g., solvent, flux, crystal lattice modifier):

This subclass is indented under subclass 13. Subject matter in which the precursor* is intentionally formulated to contain non-crystallizing component or an excess of a crystallizing component relative to another crystallizing component.

(1) Note. For example, arsenic in excess molten gallium, from which crystallizes gallium arsenide; all the gallium cannot crystallize due to a stoichiometric deficiency of available arsenic to do so.

(2) Note. Processes in which the liquid has undesired impurities which are rejected from the growing crystal at the precursor*-product interface are not proper for placement here.

SEE OR SEARCH THIS CLASS, SUBCLASS:

19+, for processes of pulling and having an intended impurity such as a dopant*.

37 Having moving solid-liquid-solid region:

This subclass is indented under subclass 11. Subject matter in which solid precursor* material is subjected to localized heating to liquefy a region, thereby forming two solid-liquid interfaces, usually substantially parallel to each other, followed by moving the means of heating or moving said solid precursor* so as to effect additional liquid formation at one interface and concomitant cooling at the other interface, thereby obtaining single-crystal* product at the trailing solidifying interface.

(1) Note. Common terminology includes crucible-free and floating zone methods.

(2) Note. This subclass and its indents include processes in which during liquefying an additional component may be introduced so as to prepare a product of different composition than the starting solid, so long as the process does not meet the criteria of crystal pulling processes.

(3) Note. See the (5) Note located in subclass 13 for discussion of distinguishing characteristics among several liquid phase processes.

SEE OR SEARCH THIS CLASS, SUBCLASS:

13+, for processes of growing while pulling crystal from a liquid, such as zone pulling or zone drawing.

219+, for corresponding apparatus other than coating apparatus.

SEE OR SEARCH CLASS:

438, Semiconductor Device Manufacturing: Process, for a process consisting of the single crystallization of a semiconductor material by a moving solid-liquid-solid region which is combined with named operations or treatments, including those noted in the Class 117 definition, section I, C, Note (4).

38 With a step of measuring, testing, or sensing:

This subclass is indented under subclass 37. Subject matter which includes the measuring, testing, or sensing of a process condition or parameter during the process.

(1) Note. Since all processes must involve control of process parameters, placement here requires more than merely a statement of controlling or operating at a certain set of conditions. Thus, not included are mere recitations of "controlling" or "maintaining." Further, merely reciting a program or cycle or time control is not sufficient for placement here.

(2) Note. Equivalent terms include examining, inspecting, observing, viewing, and monitoring.

39 With responsive control:

This subclass is indented under subclass 38. Subject matter further including a step of controlling a specified parameter or condition in response to the measured, tested, or sensed condition or parameter.

40 Liquid precursor penetrating only a portion of a single-crystal, thereby liquefying it, and single-crystal formation therefrom which adjoins the never-liquefied portion of the single-crystal (e.g., liquid wire migration):

This subclass is indented under subclass 37. Subject matter in which a single-crystal* is formed by applying a liquid precursor to liquefy (e.g., melt or dissolve) an existing single-crystal and causing or allowing the liquid region to move into the single-crystal*, thereby penetrating it, and obtaining single-crystal* product from the moving region which adjoins never-liquefied regions of the single-crystal*.

(1) Note. Cross-referencing to subclasses 902 or 923 is precluded as unnecessarily duplicative.

SEE OR SEARCH THIS CLASS, SUBCLASS:

53, for similar processes absent a moving zone in which a region of a single-crystal* is liquified, the liquid composition is adjusted (concurrently or subsequently), and then a single-crystal* is grown.

41 Precursor composition intentionally different from product (e.g., excess component, non-product forming component, dopant, non-stoichiometric precursor, travelling solvent, flux):

This subclass is indented under subclass 37. Subject matter in which the precursor* composition is intentionally different from the single-crystal* product grown therefrom, which results in an unusable residual portion.

(1) Note. The unusable residual portion of the precursor* refers to the material that would be left if the desired single-crystal* product were grown as completely as possible. Examples of processes proper for placement in this subclass are: alumina single-crystal* grown from aluminum solvent or gallium arsenide single-crystal* grown from gallium solvent.

(2) Note. Since the distribution coefficient or segregation factor of dopants* is usually not unity, a process in which a doped crystal is formed is proper for placement here, except when the reference states that the coefficient or the factor is unity.

(3) Note. Processes in which the liquid has unintended or undesired impurities which are rejected from the crystal at the precursor*-product interface are not proper for placement here.

42 Product has an element in common with the unusable residual portion:

This subclass is indented under subclass 41. Subject matter in which the product single-crystal* contains at least one element in common with the unusable residual portion of the precursor* composition.

(1) Note. The unusable residual portion of the precursor* refers to the material that would be left if the desired single-crystal* product were grown as completely as possible. Examples of processes proper for placement in this subclass are: alumina single-crystal* grown from aluminum solvent or gallium arsenide single-crystal* grown from gallium solvent.

43 Distinctly layered product (e.g., twin, SOI, epitaxial crystallization):

This subclass is indented under subclass 37. Subject matter in which the process results in a product having distinct layers.

(1) Note. All the layers need not be single-crystal*, nor do they need to be formed by the process.

(2) Note. A layer may be a seed* or merely a confining or contacting member.

44 Adjacent single-crystal product regions separately formed (e.g., multiple non-coextensive passes of a scanning laser):

This subclass is indented under subclass 43. Subject matter in which a liquid precursor* region is formed adjacent to a previously grown single-crystal* product region, and then a single-crystal* product is grown therefrom.

(1) Note. The adjacently formed product region may or may not have a common crystal lattice with the previously (or subsequently) separately formed product region.

(2) Note. Where a liquefying pass completely liquefies a previously formed single-crystal*, the proper classification will be elsewhere, based on the characteristics of the step of single-crystal* growth from the liquid.

45 Non-planar crystal grown (e.g., ELO):

This subclass is indented under subclass 43. Subject matter in which the boundary between the layer and the grown single-crystal* product is not a simple uniform plane.

(1) Note. For example, a product having recesses, mesas, etc.

46 Movement includes a horizontal component:
This subclass is indented under subclass 37. Subject matter in which the solid-liquid-solid region is caused to move in a direction which includes a horizontal component.

47 Flat, free-standing (i.e., substrate-free) product (e.g., ribbon, film, sheet):
This subclass is indented under subclass 37. Subject matter in which the single-crystal* product is free-standing (i.e., not adhering to a substrate) and is flat (i.e. has two substantially planar and parallel faces).

(1) Note. If the disclosed intent is to produce an unlayered product but the claims do not recite separation of the crystal product from its substrate, then the reference should be placed in both this subclass and in subclass 43.

(2) Note. Cross-referencing to art collection 922 is precluded as unnecessarily duplicative.

SEE OR SEARCH THIS CLASS, SUBCLASS:
43, for processes in which the flat product (e.g., ribbon, film, or sheet) is part of a layered product.

48 Solid heating means contacting the liquid (e.g., immersed):
This subclass is indented under subclass 37. Subject matter in which solid heating means contacts the liquid region.

(1) Note. The heating means may be an "indirect" heat source such as a graphite element which is heated by RF induction.

(2) Note. Not included here are techniques in which the solid precursor* itself is used as an indirect source of heating; i.e., heated by RF induction.

49 Liquid zone contacts only precursor and product solids (e.g., crucibleless, liquid encapsulant, float zone):
This subclass is indented under subclass 37. Subject matter in which the liquid region is characterized by being free of direct contact with any solid (e.g., the wall of a crucible* or the surface of a substrate) other than the precursor* and the single-crystal* product.

50 Liquefying by energy from an electromagnetic wave or electromagnetic particle or arc or plasma (e.g., radiant heat):
This subclass is indented under subclass 49. Subject matter in which the energy to liquefy is at least in part provided by electromagnetic wave or electromagnetic particle or arc or plasma (e.g., radiant energy, electric current (e.g., Peltier* effect), laser beam, RF induction, electron beam, electric discharge).

(1) Note. It is not enough for this and indented subclasses that the process uses such energy source to initiate the process; the energy must be supplied concurrent with the growth process.

51 Electromagnetic induction:
This subclass is indented under subclass 50. Subject matter in which the energy for liquefying is supplied by electric or magnetic induction phenomenon by the influence of a neighboring electric or magnetic field (e.g., radio frequency waves).

(1) Note. Heating by radiation or by electron beam is placed above in subclass 50, unless accompanied by application of a source of electromagnetic induction energy.

52 With liquid control (e.g., vibration damping, stabilizing, melt levitation, focusing coil):
This subclass is indented under subclass 51. Subject matter further including liquid control means, especially to prevent sagging of or to provide shape to the liquid region.

53 Forming a single-crystal region by liquefying a region of a single-crystal and adjusting

the composition of the liquid (e.g., alloying, regrowth):
This subclass is indented under subclass 11. Subject matter in which a region of an existing single-crystal* is liquefied and the composition of the liquid is adjusted (either simultaneously or subsequently) and the liquid is then single-crystallized*.

(1) Note. Typically this process forms a semiconductor junction*.

(2) Note. Cross-referencing to art collections 902 and 923 is precluded as unnecessarily duplicative.

SEE OR SEARCH THIS CLASS, SUBCLASS:
40, for similar processes in which a moving solid-liquid-solid region is effected.

54 Liquid phase epitaxial growth (LPE):
This subclass is indented under subclass 11. Subject matter characterized by single-crystal* growth onto a seed* where the product has a definite crystallographic relationship to the seed*, where its thickness is not greater than the same order of magnitude than its width and/or length, and where the substrate* remains as a significant or integral part of the product in use (i.e., epitaxy*).

(1) Note. See the (5) Note located in subclass 13 for discussion of distinguishing characteristics among several liquid phase processes.

SEE OR SEARCH THIS CLASS, SUBCLASS:
13+, for processes of growing while pulling crystals from a liquid.
75, for growing whiskers or needles.

SEE OR SEARCH CLASS:
118, Coating Apparatus, subclasses 400+ for corresponding apparatus.
427, Coating Processes, for processes of coating except as specifically provided for elsewhere (e.g., single-crystal* growing or onto or with semiconductor material), especially subclasses 457 through 601 for processes of coating combined with direct application of electrical, magnetic, wave, or particle energy (e.g., subclasses 581, 594, 601) and subclasses 430.1+ for immersion or partial immersion.
438, Semiconductor Device Manufacturing: Process, for a process consisting of a liquid phase epitaxial growth step of a semiconductor material which is combined with named operations or treatments, including those noted in the Class 117 definition, section I, C, Note (4).

55 With a step of measuring, testing, or sensing:
This subclass is indented under subclass 54. Subject matter which includes measuring, testing, or sensing of a process condition or parameter during the process.

(1) Note. Since all processes must involve control of process parameters, placement here requires more than merely a statement of controlling or operating at a certain set of conditions. Thus, not included are mere recitations of "controlling" or "maintaining." Further, merely reciting a program or cycle or time control is not sufficient for placement here.

(2) Note. Equivalent terms include examining, inspecting, observing, viewing, and monitoring.

56 Including change in a growth-influencing parameter (e.g., composition, temperature, concentration, flow rate) during growth (e.g., multilayer or junction or superlattice growing):
This subclass is indented under subclass 54. Subject matter in which a growth-influencing parameter, such as temperature, precursor* composition, precursor* concentration, or precursor* flow rate, is varied during growth and as a result the growth is altered, usually so that distinct layers of single-crystal* are formed or so that a single-crystal* of varying internal composition is formed (e.g., superlattice).

57 Including a sliding boat system:
This subclass is indented under subclass 56. Subject matter in which a boat (enclosed volume) containing a liquid precursor* or a substrate* slides relative to one defining wall of the boat (enclosed volume) so as to bring the precursor* in contact with the substrate*.

58 With pretreatment of epitaxy substrate (e.g., autodoping control, cleaning, polishing, leveling, masking):
This subclass is indented under subclass 54. Subject matter in which an epitaxy* substrate is treated prior to the growth step.

(1) Note. Pretreatment includes: cleaning such as etching; heating (e.g., to evolve impurities); or coating (e.g., masking), including when such coating is a separate layer in the final product or is removed in a subsequent step or is one which is absorbed into the final product (e.g., an adherence enhancing coating).

(2) Note. Preparation of an epitaxy* substrate is not a pretreatment step.

(3) Note. Not included as pretreatment are: merely heating up to operating temperature, or moving or positioning the substrate or the apparatus.

SEE OR SEARCH THIS CLASS, SUBCLASS:
56+, for processes which grow multiple single-crystal* layers or a single-crystal* of varying internal composition.

59 Including a tipping system (e.g., rotation, pivoting):
This subclass is indented under subclass 54. Subject matter in which the liquid nutrient* source is contacted with the substrate by dispensing it from a vessel containing it by a tipping motion of the vessel.

60 Including a vertical dipping system:
This subclass is indented under subclass 54. Subject matter in which vertical motion immerses the substrate in the nutrient*.

61 Including a sliding boat system:
This subclass is indented under subclass 54. Subject matter in which a boat (enclosed volume) containing a liquid precursor* or a substrate slides relative to one defining wall of the boat (enclosed volume) so as to bring the precursor* in contact with the substrate.

62 Electric current controlled or induced growth:
This subclass is indented under subclass 54. Subject matter in which an electric current is used to control or induce crystal growth.

SEE OR SEARCH CLASS:
204, Chemistry: Electrical and Wave Energy, for processes of forming a single crystal by a method set forth in that class definition and as restricted in Class 204, subclass 157.15, (9) Note. Thus, Class 204 is proper for single crystal growth processes which involve glow discharge, plasma torch, electrolysis, electrophoresis, sputtering, or vacuum arc discharge.

63 Characterized by specified crystallography of the substrate:
This subclass is indented under subclass 54. Subject matter in which the claim specifies the substrate by its crystallography (e.g., lattice orientation, Miller index).

(1) Note. Cross-referencing to art collection 902 is precluded as unnecessarily duplicative.

64 Precursor composition intentionally contains an excess component or a non-product appearing component (e.g., solvent, flux):
This subclass is indented under subclass 54. Subject matter in which the precursor* is intentionally formulated to contain a non-crystallizing component or an excess of a crystallizing component relative to another crystallizing component.

(1) Note. The unusable portion of the precursor* refers to the material that would be left if the desired single-crystal* product were grown as completely as possible. Examples of processes proper for placement in this subclass are: alu-

mina single-crystal* grown from aluminum solvent or gallium arsenide single-crystal* grown from gallium solvent.

(2) Note. Processes in which the liquid has unintended or undesired impurities which are rejected from the crystal at the precursor*-product interface are not proper for placement here.

SEE OR SEARCH THIS CLASS, SUBCLASS:

36, for similar processes using a seed pulling technique.

41+, for similar processes using a moving solid-liquid-solid zone.

68+, for non-LPE processes in which the precursor* is in a solution in which the solvent is a liquid at room temperature.

78+, for non-LPE processes in which the precursor* is in a solution and in which the solvent is a liquid at above room temperature.

65 Having an element in common:

This subclass is indented under subclass 64. Subject matter in which the product single-crystal* contains at least one element in common with the unusable portion of the precursor* composition.

(1) Note. The unusable portion of the precursor* refers to the material that would be left if the desired single-crystal* product were grown as completely as possible. Examples of processes proper for placement in this subclass are: alumina single-crystal* grown from aluminum solvent or gallium arsenide single-crystal* grown from gallium solvent.

66 Excess component or non-product appearing component contains an oxygen atom (e.g., hydrothermal):

This subclass is indented under subclass 65. Subject matter in which the intentional excess component or the intentional non-product forming component contains an oxygen atom (e.g., boric acid, lead oxide).

(1) Note. The oxygen does not have to be the element in common with the product.

67 Excess component or non-product appearing component contains a metal atom:

This subclass is indented under subclass 65. Subject matter in which the intentional excess component or the intentional non-product forming component contains a metal* atom or a metal* alloy or an intermetallic compound.

(1) Note. The metal* atom does not have to be the element in common with the product.

68 Having growth from a solution comprising a solvent which is liquid at or below 20 degrees Celsius (e.g., aqueous solution):

This subclass is indented under subclass 11. Subject matter in which the crystallizing material is present in a solution with another material which is a liquid at or below 20 degrees Celsius.

(1) Note. See the (5) Note located in subclass 13 for discussion of distinguishing characteristics among several liquid phase processes.

(2) Note. When the disclosure is generic to liquid solutions and it is not clear whether the solvent is liquid at room temperature, search and cross-references are appropriate here and in subclasses 73+.

SEE OR SEARCH THIS CLASS, SUBCLASS:

13+, for processes of growing while pulling crystals from a liquid which may be liquid at room temperature.

69 With a step of measuring, testing, or sensing:

This subclass is indented under subclass 68. Subject matter which includes measuring, testing, or sensing of a process condition or parameter during the process.

(1) Note. Since all processes must involve control of process parameters, placement here requires more than merely a statement of controlling or operating at a certain set of conditions. Thus, not included are mere recitations of "controlling" or "maintaining." Further,

merely reciting a program or cycle or time control is not sufficient for placement here.

(2) Note. Equivalent terms include examining, inspecting, observing, viewing, and monitoring.

70 Growth accompanied by material removal (other than the product) from solution (e.g., solvent evaporation, osmosis):

This subclass is indented under subclass 68. Subject matter in which material other than the single-crystal* product itself is removed from the liquid during growth; for example, solvent removal by evaporation or by osmosis.

(1) Note. Where a removed material may also be a component of the single-crystal* product, the process is still proper for placement here; for example, evaporating water while growing a hydrated phosphate single-crystal*.

71 At pressure above 1 atmosphere (e.g., hydrothermal processes):

This subclass is indented under subclass 68. Subject matter in which growth occurs under conditions of greater than 1 atmospheric pressure.

SEE OR SEARCH THIS CLASS, SUBCLASS:

224, for corresponding apparatus other than coating apparatus.

72 Quartz (SiO_2) product:

This subclass is indented under subclass 71. Subject matter in which single-crystal* silicon dioxide is grown.

(1) Note. Cross-referencing to art collection 943 is precluded as unnecessarily duplicative.

73 Having growth from molten state (e.g., solution melt):

This subclass is indented under subclass 11. Subject matter in which the liquid precursor* is a solid at room temperature, whether it is a solution or otherwise.

(1) Note. See the (5) Note located in subclass 13 for discussion of distinguishing characteristics among several liquid phase processes.

SEE OR SEARCH THIS CLASS, SUBCLASS:

19+, for processes of growing by pulling from a liquid solution containing a dopant*.

64+, for liquid phase epitaxy* using a precursor* comprising a solution.

74 Including change in a growth-influencing parameter (e.g., composition, temperature, concentration, flow rate) during growth (e.g., multilayer or junction or superlattice growing):

This subclass is indented under subclass 73. Subject matter in which a growth-influencing parameter, such as temperature, precursor* composition, precursor* concentration, or precursor* flow rate, is varied during growth and as a result the growth is altered, usually so that distinct layers of single-crystals* are formed or so that a single-crystal* of varying internal composition is formed.

SEE OR SEARCH THIS CLASS, SUBCLASS:

56+, for processes of liquid phase epitaxy* in which a change in growth-influencing parameter occurs.

75 Forming a platelet shape or a small diameter, elongate, generally cylindrical shape (e.g., whisker, fiber, needle, filament) (e.g., VLS method):

This subclass is indented under subclass 73. Subject matter in which the product formed is stated to be or appears to be a platelet shape or a small diameter, elongate, generally cylindrical shape (e.g., whisker, fiber, needle, filament).

(1) Note. Search also subclass 87 for processes in which it is not clearly evident that a liquid phase is present.

(2) Note. Cross-referencing to art collection 921 is precluded as unnecessarily duplicative.

76 Using a scavenger agent (e.g., remove, add, deplete, or redistribute impurity or dopant):
This subclass is indented under subclass 73. Subject matter in which an agent is specified to scavenge, remove, isolate, or control an impurity such as a dopant*, desired or undesired.

77 Gas or vapor state precursor or overpressure:
This subclass is indented under subclass 73. Subject matter in which an overpressure of a precursor* is used or a precursor* of the single-crystal* product is delivered during the process to the molten precursor* in the gas or vapor state.

78 Precursor composition intentionally different from product (e.g., excess component, non-product forming component, dopant, non-stoichiometric precursor, solvent, flux):
This subclass is indented under subclass 73. Subject matter in which the precursor* composition is intentionally formulated different from the single-crystal* product grown therefrom which results in an unusable residual portion.

(1) Note. The unusable residual portion of the precursor* refers to the material that would be left if the desired single-crystal* product were grown as completely as possible. Examples of processes proper for placement in this subclass are: alumina single-crystal* grown from aluminum solvent or gallium arsenide single-crystal* grown from gallium solvent.

(2) Note. Since the distribution coefficient or segregation factor of dopants* is usually not unity, a process in which a doped crystal is formed is proper for placement here, except when the reference states that the coefficient or the factor is unity.

(3) Note. Processes in which the liquid has undesired impurities which are rejected from the crystal at the precursor*-product interface are not proper for placement here.

(4) Note. Methods including evaporation of material in the precursor* composition, such as an excess component or a non-product forming component, are properly placed here.

SEE OR SEARCH THIS CLASS, SUBCLASS:
77, for processes in which the difference in compositions is due to or coupled to a gas or vapor state precursor* delivered to the melt during growth.

79 Unusable portion contains a metal atom (e.g., diamond or CBN growth in metal solvent):
This subclass is indented under subclass 78. Subject matter in which the unusable residual portion of the precursor* contains free metal*, metal* alloy, or intermetallic compound.

(1) Note. Although Class 117 is proper for original placement of single-crystal* diamond making, a mandatory search and cross-reference is found in Class 423, subclass 446, which is the locus for all diamond making processes (other the than coating processes for Class 427) and products, whether or not a chemical reaction is involved.

80 Unusable portion contains an oxygen atom (e.g., oxide flux):
This subclass is indented under subclass 78. Subject matter in which the unusable residual portion of the precursor* contains an oxygen atom (e.g., boric acid, lead oxide).

81 Growth confined by a solid member other than seed or product (e.g., Bridgman-Stockbarger method):
This subclass is indented under subclass 73. Subject matter in which a solid member, other than the seed or product, confines growth in at least one direction and at least partially defines the shape of the product; for example, a crucible* or a mold.

SEE OR SEARCH THIS CLASS, SUBCLASS:
13+, for processes of growing a single-crystal* while pulling and subclasses 16 and 23+ when the solid-liquid interface may be contacted or confined by a solid member shaping means.

43+, for processes of moving zone crystallization in which the solid-liquid interface may be confined or contacted by a solid.
54+, for processes of epitaxy*.
223, for corresponding apparatus other than coating apparatus.

82 Including vertical precursor-product interface (e.g., horizontal Bridgman):
This subclass is indented under subclass 81. Subject matter in which growth is characterized by a vertical precursor*-product interface, and therefor, the solid-liquid interface moves horizontally.

83 Having bottom-up crystallization (e.g., VFG, VGF):
This subclass is indented under subclass 81. Subject matter in which crystal growth initiates at the lowest point in the melt and progresses up; e.g., vertical freeze gradient (VFG).

84 FORMING FROM VAPOR OR GASEOUS STATE (E.G., VPE, SUBLIMATION):
This subclass is indented under the class definition. Subject matter in which the single-crystal* is grown by depositing material directly from the vapor or gaseous state; i.e., the immediate-precursor* is in a vapor or gaseous state.

SEE OR SEARCH THIS CLASS, SUBCLASS:
11+, for processes in which the crystal grows from an immediate-precursor* in a liquid or supercritical state, even if the liquid or supercritical material (or a precursor* thereof) was present as a gas or vapor state during the process.
200+, for corresponding apparatus other than coating apparatus.

SEE OR SEARCH CLASS:
118, Coating Apparatus, subclasses 715+ for corresponding VPE coating apparatus.
427, Coating Processes, for processes of depositing a coating other than single-crystal* (e.g., polycrystalline or amorphous) on a substrate, except as specifically provided for elsewhere; especially subclasses 457+ for processes of coating combined with direct application of electrical, magnetic, wave, or particle energy (e.g., subclasses 497, 509, 523+, 569+, 580, 582+, 585+, and 593), and subclasses 248.1+ for coating by vapor, gas, or smoke.
438, Semiconductor Device Manufacturing: Process, for a process consisting of a vapor of gaseous coating step of or with a semiconductor material, or for a process including a step of growing a single-crystal* of a semiconductor material which is combined with named operations or treatments, including those noted in the Class 117 definition, section I, C, Note (4).

85 With a step of measuring, testing, or sensing:
This subclass is indented under subclass 84. Subject matter which includes the measuring, testing, or sensing of a process condition or parameter during the process.

(1) Note. Since all processes must involve control of process parameters, placement here requires more than merely a statement of controlling or operating at a certain set of conditions. Thus, not included are mere recitations of "controlling" or "maintaining." Further, merely reciting a program or cycle or time control is not sufficient for placement here.

(2) Note. Equivalent terms include examining, inspecting, observing, viewing, and monitoring.

86 With responsive control:
This subclass is indented under subclass 85. Subject matter further including a step of controlling a specified parameter or condition in response to the measured, tested, or sensed condition or parameter.

87 Forming a platelet shape or a small diameter, elongate, generally cylindrical shape (e.g., whisker, fiber, needle, filament):
This subclass is indented under subclass 84. Subject matter in which the product formed is stated to be or appears to be a platelet shape or a small diameter, elongate, generally cylindri-

cal shape (e.g., whisker, fiber, needle, filament).

(1) Note. Search also subclass 75 for processes in which it is unclear whether a liquid phase is present.

(2) Note. Cross-referencing to art collections 921 or 922 is precluded as unnecessarily duplicative.

88 With decomposition of a precursor (except impurity or dopant precursor) composed of diverse atoms (e.g., CVD):

This subclass is indented under subclass 84. Subject matter in which a precursor* molecule composed of different atoms, other than an impurity or a dopant* precursor*, is involved in a decomposition chemical reaction* during the growth process.

89 Including change in a growth-influencing parameter (e.g., composition, temperature, concentration, flow rate) during growth (e.g., multilayer or junction or superlattice growing):

This subclass is indented under subclass 88. Subject matter in which a growth-influencing parameter, such as temperature, precursor* composition, precursor* concentration, or precursor* flow rate, is varied (e.g., modulated) during growth and as a result growth is altered, usually so that distinct layers of single-crystals* are formed or so that a single-crystal* of varying internal composition is formed (e.g., superlattice).

(1) Note. Variations which occur during initiating and terminating growth are not included as changes in a growth-influencing parameter.

SEE OR SEARCH THIS CLASS, SUBCLASS:

98, for movement of substrate or vapor or gas supply means during growth; e.g., rotation of wafer.

90 With pretreatment of substrate (e.g., coating, ablating):

This subclass is indented under subclass 89. Subject matter in which a substrate* is treated prior to growth.

(1) Note. Pretreatment includes: cleaning such as etching; heating (e.g., to evolve impurities); or coating, other than single-crystal* coating (e.g., masking), including when such coating is a separate layer in the final product or is removed in a subsequent step or one which is absorbed into the final product (e.g., an adherence enhancing coating).

(2) Note. Multiple single-crystal* growth processes are not proper for placement here based on one of the single-crystal* growth steps.

SEE OR SEARCH THIS CLASS, SUBCLASS:

101, for specified arrangement of or crystallographic orientation of the substrate.

91 With a chemical reaction (except ionization) in a disparate zone to form a precursor:

This subclass is indented under subclass 89. Subject matter including a step of forming a precursor*, including dopant* precursor*, by a chemical reaction* (except ionization) in a location separate from the deposition zone.

(1) Note. Not included here are processes in which the precursor* undergoes chemical reaction* immediately at the deposition zone.

(2) Note. Cross-referencing between this subclass and subclass 93 is not necessary when based on the same step or steps. However, when it is unclear whether the basis of placement is based on the same step, cross-referencing is appropriate.

SEE OR SEARCH THIS CLASS, SUBCLASS:

92, for similar processes involving ionization.

92 Using an energy beam or field, a particle beam or field, or a plasma (e.g., ionization,

PECVD, CBE, MOMBE, RF induction, laser):

This subclass is indented under subclass 89. Subject matter in which the process utilizes a particle beam or an energy beam or a particle field or an energy field or a plasma.

(1) Note. For example: laser, electron, chemical, or molecular beams; plasma; RF, magnetic, or electric fields; ionization.

(2) Note. The decomposition reaction may be related to or unrelated to the energy beam or field, particle beam or field, or plasma.

SEE OR SEARCH THIS CLASS, SUBCLASS:

90, for processes in which the substrate is pretreated with an energy or particle beam or field, or plasma.

103, for similar processes in which there is no change in a growth-influencing parameter.

SEE OR SEARCH CLASS:

204, Chemistry: Electrical and Wave Energy, for processes of forming a single crystal by a method set forth in that class definition and as restricted in Class 204, subclass 157.15, (9) Note. Thus, Class 204 is proper for single crystal growth processes which involve glow discharge, plasma torch, electrolysis, electrophoresis, sputtering, or vacuum arc discharge.

427, Coating Processes, for processes of depositing a coating other than single-crystal* (e.g., polycrystalline or amorphous) on a substrate, except as specifically provided for elsewhere, especially subclasses 457+ for processes of coating combined with direct application of electrical, magnetic, wave, or particle energy (e.g., subclasses 497, 509, 523+, 569+, 580, 582+, 585+, and 593) and subclasses 248.1+ for coating by vapor, gas, or smoke.

93 With significant flow manipulation or condition, other than merely specifying the components or their sequence or both:

This subclass is indented under subclass 89. Subject matter in which significant gas or vapor flow manipulation or condition, other than merely specifying the components of precursors*, or their sequence, or both, is specified.

(1) Note. For example: stagnant zone provided; coaxial vapor inlet described; horizontally or tangentially directed flow specified; flow through a porous medium (e.g., frit); backflow control means; laminar or turbulent flow specified; mixing order or arrangement specified (more than merely mixing); flow rates given; proportions of constituents or flows given; or specified temperature or pressure of the gas or vapor flow specified (more than specifying the temperature or pressure of the reaction chamber).

(2) Note. Not included here are claims merely reciting alternating flows or layers deposited (e.g., superlattice) absent a recitation of some significant flow manipulation or condition provided for in this subclass.

(3) Note. Cross-referencing between this subclass and subclass 91 is not necessary when based on the same step or steps.

94 With pretreatment or preparation of a base (e.g., annealing):

This subclass is indented under subclass 88. Subject matter in which a base* is prepared or is subject to treatment prior to single-crystal* growth.

(1) Note. Pretreatment includes: cleaning such as etching; heating (e.g., to evolve impurities); or coating (e.g., masking), including when such coating is a separate layer in the final product or is removed in a subsequent step or is one which is absorbed into the final product (e.g., an adherence enhancing coating).

(2) Note. Placement here is proper for claims directed to preparation of the base* when combined with a step of single-crystal* growth.

(3) Note. Not included as pretreatment are: merely heating up to operating temperature, or moving or positioning substrate or apparatus.

SEE OR SEARCH THIS CLASS, SUBCLASS:

89+, for processes which include a change in growth-influencing parameter during crystal growth; e.g., making superlattices, layers, junction.

101, for specified arrangement of or crystallographic orientation of the substrate.

106, for similar processes involving pretreatment or preparation of the substrate and not involving a decomposition reaction of the precursor*.

95 Coating (e.g., masking, implanting):
This subclass is indented under subclass 94. Subject matter in which the pretreatment is coating of the base*.

SEE OR SEARCH THIS CLASS, SUBCLASS:

89+, for processes in which multiple layers of single-crystal* are formed.

96 For autodoping control:
This subclass is indented under subclass 95. Subject matter in which there is a disclosed intent to control autodoping during growth by performing the coating.

97 Material removal (e.g., etching, cleaning, polishing):
This subclass is indented under subclass 94. Subject matter in which the pretreatment involves removing material from the base*.

(1) Note. Examples of subject matter proper for this subclass are: uniform material removal from the base* surface, such as etching or non-uniform removal such as exposing a seed* region (e.g., by removing a masking material).

98 With a movement of substrate or vapor or gas supply means during growth (e.g., substrate rotation):
This subclass is indented under subclass 88. Subject matter in which the process employed includes simultaneous growth and movement of (a) the substrate through a vapor or gas supply field or (b) the vapor or gas supply means (e.g., supply tube) relative to the substrate (e.g., rotation of the substrate in the deposition chamber).

(1) Note. This subclass does not provide for merely moving a substrate from one station to another without simultaneous deposition and movement.

99 With a chemical reaction (except ionization) in a disparate zone to form a precursor (e.g., transport processes):
This subclass is indented under subclass 88. Subject matter including a step of forming a precursor*, including dopant* precursor*, by a chemical reaction* (except ionization) in a location separate from the deposition zone.

(1) Note. Not included here are processes in which the precursor* undergoes chemical reaction* immediately at the deposition zone.

(2) Note. Cross-referencing between this subclass and subclass 102 is not necessary when based on the same step or steps. However, when it is unclear, cross-referencing is appropriate.

SEE OR SEARCH THIS CLASS, SUBCLASS:

103, for similar processes involving ionization.

100 Fully-sealed or vacuum-maintained chamber (e.g., ampoule):
This subclass is indented under subclass 99. Subject matter in which a sealed chamber (e.g., ampoule) is used or in which the only communication between a reaction chamber and the external environment is a vacuum-maintaining means.

101 Characterized by specified crystallography or arrangement of substrate (e.g., wafer cassette, Miller index):

This subclass is indented under subclass 88. Subject matter in which (a) the arrangement of the substrate is specified, for example a wafer cartridge or tray or a bank of wafers, or (b) the crystallography of the substrate is specified; e.g., crystal lattice orientation, Miller index.

(1) Note. Cross-referencing to art collection 902 is precluded as unnecessarily duplicative.

102 With significant flow manipulation or condition, other than merely specifying the components or their sequence or both:

This subclass is indented under subclass 88. Subject matter in which significant gas or vapor flow manipulation or condition, other than merely specifying the components of precursors* or their sequence or both, is specified.

(1) Note. Examples of subject matter proper for this subclass are: stagnant zone provided; coaxial vapor inlet described; horizontally or tangentially directed flow specified; flow through a porous medium (e.g., frit); backflow control means; laminar or turbulent flow specified; mixing order or arrangement specified (more than merely mixing); flow rates given; proportions of constituents or flows given; or specified temperature or pressure of the gas or vapor flow specified (more than specifying the temperature or pressure of the reaction chamber).

(2) Note. Not included here are claims merely reciting alternating flows or layers deposited (e.g., superlattice) absent a recitation of some significant flow manipulation or condition provided for in this subclass.

(3) Note. Cross-referencing between this subclass and subclass 99 is not necessary when based on the same step or steps.

103 Using an energy beam or field, a particle beam or field, or a plasma (e.g., ionization, PECVD, CBE, MOMBE, RF induction, laser):

This subclass is indented under subclass 88. Subject matter in which the process utilizes a particle beam or an energy beam or a particle field or an energy field or a plasma during growth.

(1) Note. Examples of subject matter proper for this subclass are: laser, electron, chemical, or (some) molecular beams; plasma; RF, magnetic, or electric fields; or ionization.

(2) Note. Some MBE processes are proper for this subclass, however most do not involve a decomposition reaction of a precursor*.

SEE OR SEARCH THIS CLASS, SUBCLASS:

92, for similar processes in which there is also a change in a growth-influencing parameter during growth; e.g., to grow layers, junction, superlattice.

94, for processes in which the substrate is pretreated with an energy beam or field, particle beam or field, or plasma.

108, for similar processes in which there is no chemical decomposition reaction of precursor* (e.g., most MBE processes).

SEE OR SEARCH CLASS:

204, Chemistry: Electrical and Wave Energy, for processes of forming a single crystal by a method set forth in that class definition and as restricted in Class 204, subclass 157.15, (9) Note. Thus, Class 204 is proper for single crystal growth processes which involve glow discharge, plasma torch, electrolysis, electrophoresis, sputtering, or vacuum arc discharge.

104 Using an organic precursor (e.g., propane, metal-organic, MOCVD, MOVPE):

This subclass is indented under subclass 88. Subject matter in which the product contains atoms derived from a precursor* which is an organic compound as defined in Class 532.

105 Including change in a growth-influencing parameter (e.g., composition, temperature, concentration, flow rate) during growth (e.g., multilayer or junction or superlattice growing):

This subclass is indented under subclass 84. Subject matter in which a growth-influencing parameter, such as temperature, precursor* composition, precursor* concentration, or precursor* flow rate, is varied (e.g., modulated) during growth and as a result growth is altered, usually so that distinct layers of single-crystals* are formed or so that a single-crystal* of varying internal composition is formed (e.g., superlattice).

(1) Note. Initiating and terminating growth are not included as changes in a growth-influencing parameter.

SEE OR SEARCH THIS CLASS, SUBCLASS:

107, for movement of substrate or vapor or gas supply means during growth.

106 With pretreatment or preparation of a base (e.g., annealing):

This subclass is indented under subclass 84. Subject matter in which a base* is prepared or in which a base* is subject to treatment prior to single-crystal* growth.

(1) Note. Pretreatment includes: cleaning such as etching; heating (e.g., to evolve impurities); or coating (e.g., masking), including when such coating is a separate layer in the final product or is removed in a subsequent step or is one which is absorbed into the final product (e.g., an adherence enhancing coating).

(2) Note. Placement here is proper for claims directed to preparation of the base* when combined with a step of single-crystal* growth.

(3) Note. Not included as pretreatment are: merely heating up to operating temperature, or moving or positioning substrate or apparatus.

SEE OR SEARCH THIS CLASS, SUBCLASS:

89+, for processes involving pretreatment or preparation of the substrate and involving a decomposition reaction of a precursor*.

105, for processes which include a change in growth-influencing parameter during crystal growth (e.g., making superlattice, layers, junction).

107 With movement of substrate or vapor or gas supply means during growth:

This subclass is indented under subclass 84. Subject matter in which the process employed includes simultaneous growth and movement of (a) the substrate through a supply gas or vapor field or (b) the gas or vapor supply means (e.g., supply tube) relative to the substrate; e.g., rotation of substrate in the deposition chamber.

(1) Note. This subclass does not provide for merely moving a substrate from one station to another without simultaneous crystal growth.

108 Using an energy beam or field, a particle beam or field, or a plasma (e.g., MBE):

This subclass is indented under subclass 84. Subject matter in which the process utilizes a particle beam or an energy beam or a particle field or an energy field or a plasma during growth.

(1) Note. Examples of subject matter proper for this subclass are: laser, electron, chemical, or molecular beams; plasma; or RF, magnetic, or electric fields.

109 Fully-sealed or vacuum-maintained chamber (e.g., ampoule):

This subclass is indented under subclass 84. Subject matter in which a sealed chamber (e.g., ampoule) is used or in which the only communication between a reaction chamber and the external environment is a vacuum-maintaining means.

200 APPARATUS:
This subclass is indented under the class definition. Subject matter comprising apparatus for growing single-crystal* (i.e., non-coating single-crystal* growing apparatus).

(1) Note. See section I, C and E, for defining notes for apparatus of this class.

SEE OR SEARCH CLASS:
118, Coating Apparatus, for apparatus for depositing a coating which may be single-crystal*, especially subclasses 400+ for liquid phase epitaxy* and subclasses 715+ for vapor phase epitaxy*.
156, Adhesive Bonding and Miscellaneous Chemical Manufacture, subclasses 345.1 through 345.55 for differential etching apparatus.
204, Chemistry: Electrical and Wave Energy, for apparatus for forming single crystal by class defined processes with exceptions noted at (C) and (5) Note in the class definition.
422, Chemical Apparatus and Process Disinfecting, Deodorizing, Preserving or Sterilizing, subclasses 186+ for apparatus for forming single crystals by a method of Class 204, subclasses 157.15+.

201 With means for measuring, testing, or sensing:
This subclass is indented under subclass 200. Subject matter which includes means for measuring, testing, or sensing a process condition or parameter during the process.

(1) Note. Since all processes and apparatus require controlling means in order to provide satisfactory operation, placement here requires more than merely a statement of controlling or operating at a certain set of conditions. Thus, not included are mere recitations of "means to control" absent a recitation of a means for measuring, sensing, or testing some parameter or condition. Further, merely reciting a program or cycle or time control is not sufficient for placement here.

(2) Note. Equivalent terms include examining, inspecting, observing, viewing, and monitoring.

202 With responsive control means:
This subclass is indented under subclass 201. Subject matter which includes means for controlling a specified parameter or condition in response to the measured, tested, or sensed condition or parameter.

203 With a window or port for visual observation or examination:
This subclass is indented under subclass 201. Subject matter which includes a window or port for visual (i.e., human) observation, viewing, or examination of the growth process or of an intimately related process parameter or condition.

204 With means for treating single-crystal (e.g., heat treating):
This subclass is indented under subclass 200. Subject matter in which the apparatus further includes means for treating a single-crystal*, and said means provides that the single-crystal* remains in the solid state and that the result is a single-crystal*.

SEE OR SEARCH THIS CLASS, SUBCLASS:
3, for processes of growth with a subsequent step of heat treating or deliberate controlled cooling of the single-crystal*.

205 For forming a platelet shape or a small diameter, elongate, generally cylindrical shape (e.g., whisker, fiber, needle, filament):
This subclass is indented under subclass 200. Subject matter in which the apparatus produces single-crystal* product which is stated to be or appears to be a platelet shape or a small diameter, elongate, generally cylindrical shape (e.g., whisker, fiber, needle, filament).

(1) Note. Cross-referencing to art collections 921 or 922 is precluded as unnecessarily duplicative.

SEE OR SEARCH THIS CLASS, SUBCLASS:

75, for processes forming platelet or small diameter, elongate, generally cylindrical-shaped single-crystal* from the molten state.

87, for processes forming platelet or small diameter, elongate, generally cylindrical-shaped single-crystal* from the vapor or gaseous state.

206 For crystallization from liquid or supercritical state:

This subclass is indented under subclass 200. Subject matter in which the apparatus provides means to produce a product from an immediate-precursor* which is in a liquid or supercritical state.

SEE OR SEARCH THIS CLASS, SUBCLASS:

11+, for corresponding processes.

207 Crucibleless apparatus having means providing movement of discrete droplets or solid particles to thin-film precursor (e.g., Verneuil method):

This subclass is indented under subclass 206. Subject matter in which droplets or solid particles of precursor* are moved as discrete entities to a thin-film liquid precursor* mass from which the single-crystal* product is grown and which precursor is not contained by a crucible.

SEE OR SEARCH THIS CLASS, SUBCLASS:

12, for corresponding processes.

208 Seed pulling:

This subclass is indented under subclass 206. Subject matter including features intended for seed pulling which is characterized by bringing a seed* into contact with a liquid precursor* (or nutrient*) media to initiate and conduct the growth process by then withdrawing it under conditions which permit crystal formation while pulling.

(1) Note. See subclass 13, (5) Note, for discussion of the differences between seed pulling and several other liquid state crystallization processes.

SEE OR SEARCH THIS CLASS, SUBCLASS:

13+, for corresponding processes.

209 Including solid member shaping means other than seed or product (e.g., EDFG die):

This subclass is indented under subclass 208. Subject matter including a solid member (i.e., mechanical or physical shaper or die), other than the seed or the single-crystal* product, is provided sufficiently close to the precursor*-product interface to affect, and at least partially define, the shape of the crystal as it is pulled from the liquid and passes against the shaping means.

(1) Note. The solid member may be pulled with and become attached to or embedded in the crystal; e.g., string-stabilized web pulling.

210 Means for forming a hollow structure (e.g., tube, polygon):

This subclass is indented under subclass 209. Subject matter which forms a crystal having a hollow structure.

(1) Note. Cross-referencing to art collection 920 is precluded as unnecessarily duplicative.

211 Including means forming a flat shape (e.g., ribbon):

This subclass is indented under subclass 209. Subject matter which forms a crystal having two substantially planar and parallel faces.

(1) Note. Cross-referencing to art collection 922 is precluded as unnecessarily duplicative.

212 Pulling includes a horizontal component:

This subclass is indented under subclass 211. Subject matter in which the pulling motion to form the flat single-crystal* product includes at least some horizontal component.

(1) Note. Cross-referencing to art collection 922 is precluded as unnecessarily duplicative.

213 Including a sectioned crucible (e.g., double crucible, baffle):
This subclass is indented under subclass 208. Subject matter in which the crucible* has sections clearly defined by a physical member, at least two of which sections contain liquid precursor*; e.g., double crucible*.

214 Including details of precursor replenishment:
This subclass is indented under subclass 208. Subject matter in which precursor* replenishment means are described in some detail.

(1) Note. Mere provision for precursor* replenishment is not sufficient for placement here.

SEE OR SEARCH THIS CLASS, SUBCLASS:
213, for precursor* replenishment details which involve a sectioned crucible*.

215 Including sealing means details:
This subclass is indented under subclass 208. Subject matter in which sealing means are described in some detail.

(1) Note. Mere provision for sealing means is not sufficient for placement here.

216 Including a fully-sealed or vacuum-maintained crystallization chamber (e.g., ampoule):
This subclass is indented under subclass 208. Subject matter in which the crystallization chamber is completely isolated from the exterior environment or communicates with it only through vacuum-maintaining means.

217 Including heating or cooling details (e.g., shield configuration):
This subclass is indented under subclass 208. Subject matter in which temperature affecting element or means (such as RF susceptor, radiation shield or reflector, cooling coils, or heating element) is described in some detail.

(1) Note. Mere provision for heating or cooling means or element is not sufficient for placement here.

SEE OR SEARCH CLASS:
219, Electric Heating, for electrical heating devices of generally disclosed utility and not combined with single-crystal* forming means.
373, Industrial Electric Heating Furnaces, appropriate subclasses for apparatus having a specific electrical heating structure and of generally disclosed utility and for heating a material. Class 117 takes apparatus claimed or solely disclosed for single-crystal* growing.

218 Including details of means providing product movement (e.g., shaft guides, servo means):
This subclass is indented under subclass 208. Subject matter in which an element or means for providing movement of the single-crystal* product (such as pulling or rotating linkages, a pulling carriage or guide, shaft guides, servo means, or a differential gear) is described in some detail.

(1) Note. Merely providing movement means or an element is not sufficient for placement here.

219 Having means for producing a moving solid-liquid-solid zone:
This subclass is indented under subclass 206. Subject matter including means for subjecting solid precursor* material to localized heating to liquefy a region, thereby forming two solid-liquid interfaces, usually substantially parallel to each other, followed by moving the means of heating or moving said solid precursor* so as to effect additional liquid formation at one interface and concomitant cooling at the other interface, thereby obtaining single-crystal* product at the trailing solidifying interface.

(1) Note. Common terminology includes crucible-free or floating zone melting apparatus.

(2) Note. This subclass and its indents include apparatus having means for introducing an additional component so as to prepare a product of different composition than the starting solid.

(3) Note. See the (5) Note located in subclass 13 for discussion of distinguishing characteristics among several liquid phase processes.

SEE OR SEARCH THIS CLASS, SUBCLASS:
37+, for corresponding processes.

220 Including a solid member other than seed or product contacting the liquid (e.g., crucible, immersed heating element):
This subclass is indented under subclass 219. Subject matter in which a solid member, other than the seed or single-crystal* product, contacts the crystallizing liquid.

221 Having details of a stabilizing feature:
This subclass is indented under subclass 219. Subject matter in which means for stabilizing the apparatus are provided in some detail.

(1) Note. Merely providing for stabilizing means is not sufficient for placement here.

222 Including heating or cooling details:
This subclass is indented under subclass 219. Subject matter in which temperature affecting element or means (such as RF susceptor, radiation shield or reflector, cooling coils, or heating element) is described in some detail.

(1) Note. Mere provision for heating or cooling means or element is not sufficient for placement here.

SEE OR SEARCH CLASS:
219, Electric Heating, for electrical heating devices of generally disclosed utility and not combined with single-crystal* forming means.
373, Industrial Electric Heating Furnaces, appropriate subclasses for apparatus having a specific electrical heating structure and of generally disclosed utility and for heating a material, especially subclass 17 for apparatus for zone melting by electron beam furnace and subclass 139 for apparatus for zone melting by induction heating. Class 117 takes apparatus claimed or solely disclosed for single-crystal* growing.

223 Shape defined by a solid member other than seed or product (e.g., Bridgman-Stockbarger):
This subclass is indented under subclass 206. Subject matter in which a solid member, other that the seed or the product, at least partially shapes the single-crystal* product.

SEE OR SEARCH THIS CLASS, SUBCLASS:
68+, 73+, and especially 81+, for corresponding processes.

224 Including pressurized crystallization means (e.g., hydrothermal):
This subclass is indented under subclass 206. Subject matter including means for providing or containing pressure greater than one atmosphere in the crystallization chamber during growth.

SEE OR SEARCH THIS CLASS, SUBCLASS:
71+, and 73+, for corresponding processes.

SEE OR SEARCH CLASS:
425, Plastic Article or Earthenware Shaping or Treating: Apparatus, subclass 77 for ultra-high-pressure apparatus.

CROSS-REFERENCE ART COLLECTIONS

Note. Where there is an IPC subclass (or EPO-modified IPC subclass) which substantially encompasses the subject matter of an art collection, even though it may encompass other subject matter as well, it is noted in brackets, {}.

900 APPARATUS CHARACTERIZED BY COMPOSITION OR TREATMENT THEREOF (E.G., SURFACE FINISH, SURFACE COATING):
This subclass is indented under the class definition. A collection of art in which an apparatus is specified in terms of its material of construction or in terms of a treatment of it.

SEE OR SEARCH CLASS:
118, Coating Apparatus, for apparatus for forming coatings of single-crystal* products.

422, Chemical Apparatus and Process Disinfecting, Deodorizing, Preserving, or Sterilizing, subclasses 240+ for chemical reaction of a specific material of construction (and not provided for in subclasses 129+).

901 LEVITATION, REDUCED GRAVITY, MICROGRAVITY, SPACE:
This subclass is indented under the class definition. A collection of art which discloses growing single-crystal* in outer space, suspended in air, in low gravity, or in simulated conditions thereof.

902 SPECIFIED ORIENTATION, SHAPE, CRYSTALLOGRAPHY, OR SIZE OF SEED OR SUBSTRATE:
This subclass is indented under the class definition. A collection of art which specifies the orientation, shape, crystallography, or size of the seed or substrate material (e.g., lattice orientation, Miller index).

(1) Note. A complete search would include subclasses 40, 63, and 101. Cross- referencing therewith is precluded as unnecessarily duplicative.

SEE OR SEARCH THIS CLASS, SUBCLASS:
63, for processes of making single-crystals* by liquid phase epitaxy* in which the crystallographic orientation of the substrate is specified.
101, for processes of making single-crystals* which includes a decomposition reaction of a precursor* (except an impurity or dopant precursor*) and further specifies the substrate* crystallography.

903 DENDRITE OR WEB OR CAGE TECHNIQUE:
This subclass is indented under the class definition. A collection of art which discloses employing the dendrite or web or cage technique to make single-crystal*.

904 LASER BEAM:
This subclass is indented under the class definition. A collection of art which discloses employing a laser beam in the growing of single-crystal*.

905 ELECTRON BEAM:
This subclass is indented under the class definition. A collection of art which discloses employing an electron beam in the growing of single-crystal*.

906 SPECIAL ATMOSPHERE OTHER THAN VACUUM OR INERT:
This subclass is indented under the class definition. A collection of art which discloses providing or maintaining a specified atmosphere, other than vacuum or inert, during single-crystal* growing.

907 Refluxing atmosphere:
A collection of art under the art collection 906 wherein the atmosphere contains a component which is in the single-crystal* and which is condensed and evaporated during the growing of the single-crystal*.

910 DOWNWARD PULLING:
This subclass is indented under the class definition. A collection of art involving the downward pulling of the growing single-crystal*.

911 SEED OR ROD HOLDERS:
This subclass is indented under the class definition. A collection of art disclosing apparatus which includes means for holding or manipulating a seed or a substrate which is intended to facilitate single-crystal* growing.

912 REPLENISHING LIQUID PRECURSOR, OTHER THAN A MOVING ZONE:
This subclass is indented under the class definition. A collection of art disclosing replenishing the liquid nutrient* for single-crystal* formation other than a moving zone type of process.

(1) Note. A complete search would include subclass 33. Cross-referencing therewith is precluded as unnecessarily duplicative.

913 GRAPHOEPITAXY OR SURFACE MODIFICATION TO ENHANCE EPITAXY:
This subclass is indented under the class definition. A collection of art which discloses modifying the surface of an epitaxy* substrate* to enhance or improve the growth or the product.

914 CRYSTALLIZATION ON A CONTINUOUS MOVING SUBSTRATE OR COOLING SURFACE (E.G., WHEEL, CYLINDER, BELT):
This subclass is indented under the class definition. A collection of art which discloses growing single-crystal* on a continuous moving substrate* or cooling surface, such as a wheel, conveyor, or drum.

915 SEPARATING FROM SUBSTRATE:
This subclass is indented under the class definition. A collection of art which discloses separating a single-crystal* from its seed* or substrate*.

916 OXYGEN TESTING:
This subclass is indented under the class definition. A collection of art which discloses detecting oxygen during the growth of the single-crystal* product.

917 MAGNETIC:
This subclass is indented under the class definition. A collection of art which discloses using a magnet during the growth of the single-crystal* product.

(1) Note. A complete search would include subclass 32. Cross-referencing therewith is precluded as unnecessarily duplicative.

918 SINGLE-CRYSTAL WAVEGUIDE:
This subclass is indented under the class definition. A collection of art which discloses growing single-crystal* intended for use as a waveguide.

SEE OR SEARCH CLASS:
385, Optical Waveguides, for passive optical elements effecting a deviation of light rays or a modification in the character or properties of the light, especially subclasses 129+ for planar optical waveguides.

919 Organic:
A collection of art under the art collection 918 in which the crystal is composed of organic material.

920 SINGLE-CRYSTALS HAVING A HOLLOW (E.G., TUBE, CONCAVO-CONVEX) {C30B 29/66}:
This subclass is indented under the class definition. A collection of art which discloses growing single-crystal* having a hollow such as a tube.

(1) Note. A complete search would include subclasses 25 and 210. Cross-referencing therewith is precluded as unnecessarily duplicative.

921 SMALL DIAMETER, ELONGATE, GENERALLY CYLINDRICAL SINGLE-CRYSTAL (E.G., WHISKERS, NEEDLES, FILAMENTS, FIBERS, WIRES) {C30B 29/62}:
This subclass is indented under the class definition. A collection of art which discloses growing small diameter, elongate, generally cylindrical single-crystal* such as whiskers, needles, filaments, fibers, or wires.

(1) Note. A complete search would include subclasses 75, 87, and 205. Cross- referencing therewith is precluded as unnecessarily duplicative.

SEE OR SEARCH THIS CLASS, SUBCLASS:
75, for processes of growing small diameter, elongate, generally cylindrical single-crystal* from a melt.
87, for processes of growing small diameter, elongate, generally cylindrical single-crystal* from vapor or gas state.
205, for apparatus for growing small diameter, elongate, generally cylindrical single-crystal*.

SEE OR SEARCH CLASS:
75, Specialized Metallurgical Processes, Compositions for Use Therein, Consolidated Metal Powder Compositions, and Loose Metal Particulate Mixtures, art collections 952 and 954 for metal* whiskers or flakes.

922 FREE-STANDING, FLAT SINGLE-CRYSTAL (E.G., PLATELET, PLATE, STRIP,

DISK, TAPE, SHEET, RIBBON) {C30B 29/64}:

This subclass is indented under the class definition. A collection of art which discloses growing single-crystal* of substantially flat shape (having two substantially planar and parallel faces); e.g., plate, strip, disk, tape, sheet, or ribbon.

(1) Note. A complete search would include subclasses 16, 26, 27, 47, 87, 211, and 212. Cross-referencing therewith is precluded as unnecessarily duplicative.

SEE OR SEARCH THIS CLASS, SUBCLASS:

16, for processes of growing shaped single-crystal* by pulling method including responsive control.

26+, for processes of growing flat single-crystal* by pulling method.

47, for processes of growing flat, free-standing single-crystal* by moving zone method.

903, for dendrite-containing, flat-shaped single-crystal*.

SEE OR SEARCH CLASS:

75, Specialized Metallurgical Processes, Compositions for Use Therein, Consolidated Metal Powder Compositions, and Loose Metal Particulate Mixtures, art collections 952 and 954 for metal* whiskers or flakes.

923 SINGLE-CRYSTAL OF COMPLEX GEOMETRY (E.G., PATTERNED, ELO) {C30B 29/66}:

This subclass is indented under the class definition. A collection of art which discloses growing single-crystal* having complex geometric shapes such as patterns, ELO products, or dental braces.

(1) Note. A complete search would include subclasses 40 and 53. Cross-referencing therewith is precluded as unnecessarily duplicative.

924 HOMOGENEOUS COMPOSITION PRODUCT WITH ENLARGED CRYSTALS OR ORIENTED-CRYSTALS (E.G., COLUMNAR):

This subclass is indented under the class definition. A collection of art which discloses processing homogeneous (single composition) material having multiple crystals which are intentionally enlarged or are oriented-crystal*.

925 ORGANIC COMPOUND CONTAINING SINGLE-CRYSTAL {C30B 29/54}:

This subclass is indented under the class definition. A collection of art which discloses growing a single-crystal* comprising an organic compound.

926 Tartrate containing (e.g., Rochelle salt) {C30B 29/56}:

A collection of art under art collection 925 disclosing growing a single-crystal* comprising tartrate or a salt thereof.

SEE OR SEARCH CLASS:

562, Organic Compounds -- Part of the Class 532-570 Series, subclass 580 for methods of purification or recovery of tartrate.

927 Macromolecular compound containing (i.e., more than about 100 atoms) {C30B 29/58}:

A collection of art under art collection 925 disclosing growing a single-crystal* comprising an organic molecule having more than about 100 atoms (e.g., proteins, polymers).

928 SINGLE-CRYSTAL OF PURE OR INTENTIONALLY DOPED ELEMENT {C30B 29/02}:

This subclass is indented under the class definition. A collection of art which discloses growing a pure or intentionally doped* single-crystal* of an element.

SEE OR SEARCH CLASS:

164, Metal Founding, subclasses 122.1+ for methods of forming directionally solidified material, especially subclass 122.2 for methods of forming single crystal material, in all cases being non-semiconductor metals*, alloys, or intermetallics in a mold.

252, Compositions, subclasses 62.3+ for barrier layer compositions, per se (i.e., dopant* containing semiconductor materials).

929 Carbon (e.g., diamond) {C30B 29/04}:
A collection of art under art collection 928 disclosing growing carbon single-crystal*.

SEE OR SEARCH THIS CLASS, SUBCLASS:
79, for single-crystal* growth from a molten liquid using a precursor* of different composition than the single-crystal* product and where the unusable portion of the precursor* contains free metal*, alloy, or intermetallic; e.g., diamond growth from metal* solvent.

SEE OR SEARCH CLASS:
423, Chemistry of Inorganic Compounds, subclass 446 for diamond products and methods of making same.

930 Silicon from solid or gel state {C30B 29/06}:
A collection of art under art collection 928 disclosing growing silicon single-crystal* grown from the solid or gel state.

SEE OR SEARCH CLASS:
252, Compositions, subclasses 62.3+ for barrier layer compositions, per se (i.e., dopant* containing semiconductor materials).

931 Silicon from liquid or supercritical state {C30B 29/06}:
A collection of art under art collection 928 disclosing growing silicon single-crystal* grown from the liquid or supercritical state.

SEE OR SEARCH CLASS:
252, Compositions, subclasses 62.3+ for barrier layer compositions, per se (i.e., dopant* containing semiconductor materials).

932 By pulling {C30B 29/06}:
A collection of art under art collection 931 disclosing growing silicon single-crystal* grown from the liquid or supercritical state by a pulling technique.

933 By moving zone (not Verneuil) {C30B 29/06}:
A collection of art under art collection 931 disclosing growing silicon single-crystal* grown from the liquid or supercritical state by a moving zone technique, but excluding all Verneuil.

934 By liquid phase epitaxy {C30B 29/06}:
A collection of art under art collection 931 disclosing growing silicon single-crystal* grown from the liquid or supercritical state by a liquid phase epitaxy* technique.

935 Silicon from vapor or gaseous state {C30B 29/06}:
A collection of art under art collection 928 disclosing growing silicon single-crystal* grown from the vapor or gaseous state.

SEE OR SEARCH CLASS:
252, Compositions, subclasses 62.3+ for barrier layer compositions, per se (i.e., dopant* containing semiconductor materials).

936 Germanium {C30B 29/08}:
A collection of art under the art collection 928 disclosing growing germanium single-crystal*.

SEE OR SEARCH CLASS:
252, Compositions, subclasses 62.3+ for barrier layer compositions, per se (i.e., dopant* containing semiconductor materials).

937 INORGANIC CONTAINING SINGLE-CRYSTAL (E.G., COMPOUND, MIXTURE, COMPOSITE) {C30B 29/10}:
This subclass is indented under the class definition. A collection of art which discloses growing a single-crystal* comprising an inorganic compound or a mixture or a composite.

SEE OR SEARCH THIS CLASS, SUBCLASS:
928, for a collection of art disclosing growing single-crystal* of pure or intentionally doped element.

SEE OR SEARCH CLASS:
164, Metal Founding, subclasses 122.1+ for methods of forming directionally solidified material, especially subclass 122.2 for methods of forming single crystal, in all cases being non-semiconductor metals*, alloys, or intermetallics in a mold.

252, Compositions, appropriate subclasses for various special use and miscellaneous compositions, per se, which may be in the form of single crystal, especially see subclasses 62.3+ for barrier layer compositions (i.e., dopant* containing semiconductor materials).

501, Compositions: Ceramic, for compositions of ceramic materials, especially subclass 86 for synthetic single-crystal* composition of gem quality.

938 Gold, silver, or platinum containing {C30B 29/52}:

A collection of art under the art collection 937 disclosing growing a single-crystal* comprising gold, silver, or platinum.

939 Free metal or intermetallic compound or silicon-metal compound based, except arsenic (e.g., alloys, SiGe, InSb) {C30B 29/40, 29/52}:

A collection of art under the art collection 937 disclosing growing a single-crystal* comprising free metal* or intermetallic compound or silicon-metal* compound; except arsenic.

(1) Not. Included in this subclass are such inorganic compounds as PbTe.

(2) Note. In this subclass, arsenic is excluded from the elements defined as metal*.

SEE OR SEARCH THIS CLASS, SUBCLASS:

928, for a collection of art disclosing growing pure or intentionally doped single-crystal* of an element.

930, 931+ and 935, for a collection of art disclosing growing pure or intentionally doped single-crystal* of silicon.

954, for a collection of art disclosing growing single-crystal* comprising gallium arsenide and mixed crystals thereof (e.g., GaAs, GaAlAs).

SEE OR SEARCH CLASS:

148, Metal Treatment, subclass 404 for stock material of the class formed by directional solidification; e.g., so as to form columnar crystals.

164, Metal Founding, subclasses 122.1+ for methods of forming directionally solidified material, especially subclass 122.2 for methods of forming single crystal, in all cases being a non-semiconductor metal*, alloy, or intermetallic in a mold.

940 Halide containing (e.g., fluorphlogopite, fluor-mica) {C30B 29/12}:

A collection of art under the art collection 937 disclosing growing a single-crystal* comprising a halogen compound.

941 Phosphorus-oxygen bond containing (e.g., phosphate (PO_4)) {C30B 29/14}:

A collection of art under the art collection 937 disclosing growing a single-crystal* comprising a compound having a phosphorus-oxygen bond such as an acid, its salt, or its complex, including the phosphoric acids: hypophosphate ($M_4P_2O_6$), orthophosphate (M_3PO_4), metaphosphate (MPO_3), pyrophosphate ($M_4P_2O_7$), or polyphosphates ($M_{x+2}P_xO_{3x+1}$).

942 Silicon-oxygen bond containing (e.g., emerald, beryl, garnet, mica) {C30B 29/16}:

A collection of art under the art collection 937 disclosing growing a single-crystal* comprising a compound having a silicon-oxygen bond such as silicates, emerald, beryl, garnet, or mica.

943 Quartz (SiO_2) {C30B 29/18}:

A collection of art under the art collection 942 disclosing growing a single-crystal* comprising quartz (SiO_2).

(1) Note. A complete search would include subclass 72. Cross-referencing therewith is precluded as unnecessarily duplicative.

SEE OR SEARCH THIS CLASS, SUBCLASS:

72, for processes of growing quartz single-crystal* by a hydrothermal method.

224, for apparatus providing pressure for single-crystal* growth; e.g., hydrothermal methods.

SEE OR SEARCH CLASS:

501, Compositions: Ceramic, subclass 86 for synthetic precious stones and methods of making same when not proper for Class 117.

944 Oxygen compound containing (e.g., yttria stabilized zirconia) {C30B 29/16}:

A collection of art under the art collection 937 disclosing growing a single-crystal* comprising a compound containing oxygen.

945 Containing $A_3Me_5O_{12}$ ($1.5(A_2O_3):2.5(Me_2O_3)$), wherein A is trivalent and selected from the group Sc, Y, La, Hf, or a rare earth metal and Me is trivalent and selected from the group Fe, Ga, Sc, Cr, Co, or Al (e.g., non-silicate garnets) {C30B 29/28}:

A collection of art under the art collection 944 disclosing growing a single-crystal* comprising a compound with the formula $A_3Me_5O_{12}$, wherein A is trivalent and selected from the group Sc, Y, La, Hf, or a rare earth metal and Me is trivalent and selected from the group Fe, Ga, Sc, Cr, Co, or Al; e.g., non-silicate garnets.

946 Containing AMe_2O_4 ($AO:(Me_2O_3)$), wherein A is divalent and selected from the group Mg, Ni, Co, Mn, Zn, or Cd and Me is trivalent and selected from the group Fe, Ga, Sc, Cr, Co, or Al (e.g., spinels) {C30B 29/26}:

A collection of art under the art collection 944 disclosing growing a single-crystal* comprising a compound with the formula AMe_2O_4, wherein A is divalent and selected from the group Mg, Ni, Co, Mn, Zn, or Cd and Me is trivalent and selected from the group Fe, Ga, Sc, Cr, Co, or Al; e.g., specific spinels.

SEE OR SEARCH THIS CLASS, SUBCLASS:

949, for titanates that may have spinel structure.

947 Containing $AMeO_3$ ($(A_2O_3):(Me_2O_3)$), wherein A is trivalent and selected from the group Sc, Y, La, Hf, or a rare earth metal and Me is trivalent and selected from the group Fe, Ga, Sc, Cr, Co, or Al (e.g., Perovskite structure, ortho-ferrites) {C30B 29/24}:

A collection of art under the art collection 944 disclosing growing a single-crystal* comprising a compound with formula $AMeO_3$,wherein A is trivalent and selected from the group Sc, Y, La, Hf, or a rare earth metal and Me is trivalent and selected from the group Fe, Ga, Sc, Cr, Co, or Al (e.g., Perovskite structure, ortho-ferrites).

948 Niobate, vanadate, or tantalate containing {C30B 29/30}:

A collection of art under the art collection 944 disclosing growing a single-crystal* comprising an acid, or its salt, or its complex, of niobium ($MNbO_3$, $M_8Nb_6O_{19}$), vanadium (M_3VO_4, MVO_3, $M_4V_2O_7$), or tantalum ($MTaO_3$, $M_8Ta_6O_{19}$, M_8TaO_8).

949 Titanate, germanate, molybdate, or tungstate containing {C30B 29/32}:

A collection of art under the art collection 944 disclosing growing a single-crystal* comprising an acid, or its salt, or its complex, of titanium (M_2TiO_3, M_4TiO_4), germanium ($MGeO_3$), molybdenum (M_2MoO_4, $M_2Mo_2O_7$, $M_6Mo_7O_{24}$), or tungsten (M_2WO_4, $M_2W_4O_{13}$, $M_{10}W_{12}O_{41}$).

950 Aluminum containing (e.g., Al_2O_3, ruby, corundum, sapphire, chrysoberyl) {C30B 29/20}:

A collection of art under the art collection 944 disclosing growing a single-crystal* comprising aluminum or a compound thereof.

951 Carbide containing (e.g., SiC) {C30B 29/36}:

A collection of art under the art collection 937 disclosing growing a single-crystal* comprising a carbide compound.

952 Nitride containing (e.g., GaN,cBN,BN) {C30B 29/38}:

A collection of art under the art collection 937 disclosing growing a single-crystal* comprising a nitride compound.

953 {B,Al,Ga,In,Tl}{P,As,Sb,Bi} compound containing, except intermetallics thereof (i.e., except {Al,Ga,In,Tl}{Sb,Bi}) {C30B 29/40}:

A collection of art under the art collection 937 disclosing growing a single-crystal* comprising a compound of the formula {B,Al,Ga,In,Tl} {P,As,Sb,Bi}, except the intermetallics thereof {Al,Ga,In,Tl}{Sb,Bi}.

SEE OR SEARCH THIS CLASS, SUBCLASS:

939, for III-V compounds which comprise an intermetallic compound such as InSb.

SEE OR SEARCH CLASS:

252, Compositions, subclasses 62.3+ for barrier layer compositions, per se (i.e., dopant* containing semiconductor materials).

954 Gallium arsenide containing (e.g., GaAlAs, GaAs) {C30B 29/42}:

A collection of art under the art collection 953 disclosing growing a single-crystal* comprising gallium arsenide.

SEE OR SEARCH CLASS:

252, Compositions, subclasses 62.3+ for barrier layer compositions, per se (i.e., dopant* containing semiconductor materials).

955 Gallium phosphide containing {C30B 29/44}:

A collection of art under the art collection 953 disclosing growing a single-crystal* comprising gallium phosphide.

SEE OR SEARCH CLASS:

252, Compositions, subclasses 62.3+ for barrier layer compositions, per se (i.e., dopant* containing semiconductor materials).

956 {Zn,Cd,Hg}{S,Se,Te} compound containing {C30B 29/46}:

A collection of art under the art collection 937 disclosing growing a single-crystal* comprising a compound of the formula {Zn,Cd,Hg}{S,Se,Te}.

SEE OR SEARCH THIS CLASS, SUBCLASS:

944+, for oxygen containing compounds.

SEE OR SEARCH CLASS:

252, Compositions, subclasses 62.3+ for barrier layer compositions, per se (i.e., dopant* containing semiconductor materials).

957 CdHgTe containing {C30B 29/48}:

A collection of art under the art collection 956 disclosing growing a single-crystal* comprising cadmium mercury telluride.

SEE OR SEARCH CLASS:

252, Compositions, subclasses 62.3+ for barrier layer compositions, per se (i.e., dopant* containing semiconductor materials).

958 Cadmium sulfide containing (e.g., ZnCdS) {C30B 29/50}:

A collection of art under the art collection 956 disclosing growing a single-crystal* comprising cadmium sulfide.

SEE OR SEARCH CLASS:

252, Compositions, subclasses 62.3+ for barrier layer compositions, per se (i.e., dopant* containing semiconductor materials).

END