CLASS 977, NANOTECHNOLOGY

SECTION I - CLASS DEFINITION

CROSS-REFERENCE ART COLLECTIONS

This Nanotechnology art collection provides for disclosures related to:

(1) Nanostructure and chemical compositions of nanostructure;
(2) Device that include at least one nanostructure;
(3) Mathematical algorithms, e.g., computer software, etc., specifically adapted for modeling configurations or properties of nanostructure;
(4) Methods or apparatus for making, detecting, analyzing, or treating nanostructure; and
(5) Specified particular uses of nanostructure.

As used above, the term "nanostructure" is defined to mean an atomic, molecular, or macromolecular structure that:

(a) Has at least one physical dimension of approximately 1-100 nanometers; and
(b) Possesses a special property, provides a special function, or produces a special effect that is uniquely attributable to the structure's nanoscale physical size.

(1) Note: It should be noted that this is a cross-reference collection of art only and will not, therefore, take for original placement any U.S. Patent.

(2) Note: Class 977 generally does not cover chemical or biological structures, *per se*, specifically provided for elsewhere. That is, a compound, element, or composition of matter of nanoscale dimension is not considered to be sufficient by itself for placement in Class 977. Compounds, elements, composites, and compositions of matter of nanoscale dimension are placed in the U.S. Patent Classification system (USPC) where such compounds, elements, composites, and compositions of matter are classifiable unless they have particularly shaped configurations (e.g., fullerenes and fullerene-like structures) formed during manufacture which impart special properties or functions to the nanostructural assemblage related to the altering of basic chemical or physical properties attributed to the nanoscale.

(3) Note. Special properties and functionalities should be interpreted broadly, and are defined as those properties and functionalities that are significant, distinctive, non-nominal, noteworthy, or unique as a result of the nanoscale dimension. In general, differences in properties and functionalities that constitute mere differences of scale are insufficient to warrant inclusion of the subject matter in Class 977. The following non-limiting examples illustrate the distinction between mere scaling of size attributes vs. special attributes unique to nanoscale dimensions:

(a) A conductor of nanoscale width that exhibits substantially the same electrical properties (albeit scaled down) as when the same conductor has a substantially larger width (and has no other special properties) would not be classifiable in Class 977. However, a conventional conductor that exhibits quantum confinement or superconductivity only when formed so as to have a nanoscale width would be classifiable in Class 977.

(b) Nanosized catalyst and solid sorbent particles or catalyst and solid sorbents having nanosized pores are only classified in this class if it is shown that they achieve a unique property as a result of the nanoscale dimension. This does not include the benefits of having a higher specific surface area or a higher porosity, which naturally follow from a reduction in particle size or pore size.

(4) Note. The subject matter to be found here is limited to the stated range of nanoscale dimension solely for *physical* dimension. This includes physical dimensions that may be less than 1 nanometer (e.g., on the order of Angstroms) or slightly larger than 100 nanometers. Non-physical nanoscale dimensions are excluded from the scope of Class 977. The following are non-limiting examples of subject matter having non-physical nanoscale dimensions that are generally excluded from Class 977:

(a) Electromagnetic radiation with wavelengths on the order of 1–100 nanometers (i.e., extreme UV to soft X-ray wavelengths), as well as related materials, devices and methods for producing or for detecting wavelengths within this range;

(b) Nanoscale effects or phenomena pertaining solely to electrical fields, electric potentials or charge carriers when the underlying physical structures that produce these phenomena or effects do not, themselves, have nanoscale dimensions: e.g., charge depletion regions, carrier energy-band bending effects, or 2-dimensional carrier gases that exist within a region of less than a 100 nm width, but that are produced at the junction of two layers, which in turn, each have physical thicknesses substantially greater than 100 nm.

(5) Note. Apparatus for manufacturing nanostructures, nanomaterials and nanodevices under the scope of Class 977 is generally limited to apparatus specifically adapted for creating ordered structures on a nanometer scale, i.e. apparatus for "bottom up" manufacturing to create larger structures from atomic and molecular constituents. Apparatus for "top down" bulk manufacturing of nanostructures, nanomaterials and nanodevices are generally excluded from this Class.

(6) Note. The subject matter to be found here is generally limited to subject matter that is not specifically provided for elsewhere within the primary classification areas of the U.S. Patent Classification System even if this subject matter may otherwise satisfy the stated definition of nanotechnology. The following are non-limiting examples of subject matter that is generally excluded from coverage by Class 977 for the following reasons:

(a) Quantum well, quantum barrier, and superlattice structures not specifically provided for in this Class, and which are more specifically provided for in Class 257 Active Solid State Devices (see Section III below, Class 257);

(b) Molecular sieves and nanosized pores in catalysts, solid sorbents, and supports therefor (See Section III, below, Class 502);
(c) Colloids and solid sorbents, as well as processes of making (See Section III, below, Class 516);
(d) Devices possessing non-quantum-well or non-quantum-barrier nanosheets (e.g., double-heterojunction p-i-n LEDs or p-i-n photodetectors having a non-quantum well active layer with a thickness within the range of 1–100 nm, etc.) or associated methods of making that are not specifically provided for in the present cross-reference class, and which are more specifically provided for elsewhere in Class 257 Active Solid State Devices (e.g., Transistors, Solid-State Diodes) subclasses 79+ for incoherent light emitter structures, or subclasses 428+ responsive to electromagnetic or particle radiation or light; or elsewhere in Class 438 Semiconductor Device Manufacturing Process, subclasses 22+ for making device or circuit emissive of nonelectrical signal or subclasses 57+ for making device or circuit responsive to electromagnetic radiation;
(e) Devices possessing nanosheet buffer layers that are not specifically provided for in the present cross-reference class, and which are more specifically provided for elsewhere in Class 257--Active Solid State Devices (e.g., Transistors, Solid-State Diodes) subclass 190 heterojunction device with lattice constant mismatch (e.g., with buffer layer to accommodate mismatch, etc.);
(f) Nanosheets that function as refractive, reflective, antireflective or light-shielding coatings or layers (e.g., optical waveguides and Distributed Bragg Reflectors, etc.) or associated methods of making that are not specifically provided for in the present cross-reference class, and which are more specifically provided for elsewhere in Class 257--Active Solid State Devices (e.g., Transistors, Solid-State Diodes); Class 385--Optical Waveguides; Class 372--Coherent Light Generators; or Class 438--Semiconductor Device Manufacturing: Process subclasses;
(g) Nanosheets in heterojunction devices serving functions besides, or in addition to, buffering lattice mismatches or enhancing optical properties that are not specifically provided for in the present cross-reference class, and which are more specifically provided for elsewhere in Class 257--Active Solid State Devices (e.g., Transistors, Solid-State Diodes), subclasses 183+ for heterojunction devices (e.g., HEMTs and MESFETs, etc., having a nanosheet channel layer regardless of whether a two-dimensional carrier gas is produced);
(h) Devices possessing tunneling junctions that are not specifically provided for in Class 977, and which are more specifically provided for elsewhere in Class 257 Active Solid State Devices (e.g., Transistors, Solid-State Diodes) subclasses 104+ for tunneling pn junction (e.g., Esaki diode, etc.) devices;
(i) Electron field emitters (e.g., pointed “Spindt emitters,” etc., wherein the emitter tips’ radius of curvature is less than 100 nm) or associated methods of making that are not specifically provided for in Class 977, and which are more specifically provided for elsewhere in Class 257 Active Solid State Devices (e.g., Transistors, Solid-State Diodes) subclasses 10+ for low workfunction layer for electron emission (e.g., photocathode electron emissive layer, etc.).

SECTION II - REFERENCES TO OTHER CLASSES

SEE OR SEARCH CLASS:

73, Measuring and Testing, subclass 105 for atomic force microscope which scans a tip across the surface of a sample and monitors the deflection of the tip caused by atomic forces between the atoms in the tip and the atoms in the sample.

75, Specialized Metallurgical Processes, Compositions for Use Therein, Consolidated Metal Powder Compositions, and Loose Metal Particulate Mixtures, appropriate subclasses based on metal powder composition, subclasses 255-254 for compositions which comprise loose particles or a metal or alloy mixed with loose particles of a different metal or alloy or with loose particles of a nonmetal, subclasses 331+ for processes of producing metal or alloy particulates directly from liquid metal, and subclasses 343+ for processes of producing metal or alloy powder (i.e., under 1,000 microns in its largest dimension).

117, Single-Crystal, Oriented-Crystal, and Epitaxy Growth Processes, Non-Coating Apparatus Therefor, particularly subclasses 4-10 for processes of crystal growth from solid or gel state, and subclasses 84-109 for processes of crystal growth from vapor state wherein the growth occurs by atomic layer deposition, e.g., atomic layer epitaxy, etc.

118, Coating Apparatus, subclasses 715-733 for gas or vapor deposition apparatus, and particularly subclass 723 for ion cluster beam deposition apparatus.

148, Metal Treatment, subclasses 33-33.6 for barrier layer stock material, including electrically semiconductive superlattices formed via atomic layer deposition, e.g., atomic layer epitaxy, etc., subclasses 95+ for processes of modifying or maintaining the internal physical structure (i.e., microstructure) of metal or metal alloys such as by the creation of nanosized precipitates via age hardening, and subclasses 400+ for products of a Class 148 process.

201, Distillation: Processes, Thermolytic, appropriate subclasses- for thermolytic distillation processes limited to the heating of a solid carbonaceous material (distilland) to vaporize the portion volatile under the conditions employed and to cause a compound or compounds in the material to undergo chemical decomposition (thermolysis) to form different chemical substances, at least some of which are volatile under the condition employed and an unvaporized solid carbonaceous material.

250, Radiant Energy, subclass 216for near-field scanning optical microscope wherein light is directed through an aperture having a diameter less than the wavelength of the light and the aperture is located adjacent to a surface to be observed and scanned across the surface, and subclasses 306 and 307 for scanning tunneling microscopes and methods of using them, respectively, wherein a potential voltage is applied across a conductive sample and a conductive tip is scanned across the sample without actually contacting the sample and the current of the electrons tunneling across the gap between the sample and the tip is monitored. .

257, Active Solid State Devices (e.g., Transistors, Solid-State Diodes) subclasses 9+ for thin active physical layer which is (1) an active potential well layer thin enough to establish discrete quantum energy levels or (2) an active barrier layer thin enough to permit quantum mechanical tunneling or (3) an active layer thin enough to permit carrier transmission with substantially no scattering (e.g., superlattice quantum well or ballistic transport device, etc.); subclasses 10+ for low workfunction layer for electron emission (e.g., photocathode electron emissive layer, etc.); subclasses 40, 42, 43, 76-78, and 613+ for semiconductors possessing specified organic or inorganic material compositions; subclasses 79+ for incoherent light emitter structures and associated optical elements; subclasses 104+ for tunneling pn junction (e.g., Esaki diode, etc.) devices; subclasses 183+ for heterojunction devices including subclass 190 heterojunction device with lattice constant mismatch (e.g., with buffer layer to accommodate mismatch, etc.); subclass 194 for high electron mobility transistors (HEMTs); and subclasses 428+ for devices responsive to electromagnetic or particle radiation or light and associated optical elements.

310, Electrical Generator or Motor Structure, subclass 311 for piezoelectric elements and devices of the type used to move scanning probe microscopes with nanometric resolution.

313, Electric Lamp and Discharge Devices, subclasses 346+ and 373+ for photoemissive cathodes and subclasses 527, 530, 541, and 542+ for photocathodes in general.

324, Electricity: Measuring and Testing, subclasses 244 and 260 for a scanning magnetic force microscopes; subclasses 300+ for scanning electron paramagnetic resonance microscopes for using magnetic resonance with a scanning probe to detect atomic structure in a sample surface; and subclasses 658+ for scanning capacitance microscopes.

372, Coherent Light Generators, subclasses 43+ for semiconductor devices having (1) quantum wells and/or barriers for producing coherent light; and (2) waveguides, Distributed Bragg Reflector, and other optical elements.

374, Thermal Measuring and Testing, subclasses 6, 43, 45, and 120+ for scanning thermal microscopes.

385, Optical Waveguides, appropriate subclasses for nanosheets that function as refractive, reflective, antireflective or light-shielding coatings or layers (e.g., optical waveguides and Distributed Bragg Reflectors, etc.)

420, Alloys or Metallic Composition, appropriate subclasses, particularly those subclasses based on alloy compositions.

423, Chemistry of Inorganic Compounds, subclass 445 for fullerenes in essentially pure form.

428, Stock Material or Miscellaneous Articles, appropriate subclasses, particularly subclass 408 for self-sustaining carbon mass (e.g. bulk structure or layer comprising fullerene or fullerene-like structures, etc.); subclasses 411.1+ for non-structural laminates and subclasses 323+ layer containing structurally defined particles; subclass 446 and subclass 451 for laminates comprising a layer of silicon and a layer of silicon next to addition polymers; subclasses 544+ for structures of all metal or with adjacent metals; subclasses 688+ for non-structural laminates of inorganic materials and subclass 620 for all metal composite where one of the layers is a semiconductor layer; subclasses 689+ for non-structural laminates of inorganic metal compound containing layer (e.g. ceramics, etc.).

438, Semiconductor Device Manufacturing: Process, subclasses 22+ for making devices or circuits emissive of nonelectrical signal, subclasses 29, 65, and 69-72 for making light emitters and detectors with optical elements; and subclasses 57+ for making devices or circuits responsive to electromagnetic radiation.

501, Ceramic Composition, particular subclasses based on composition of ceramic powder

502, Catalyst, Solid Sorbent, or Support Therefor: Product or Process of Making, appropriate subclasses for catalyst or solid sorbents and methods of manufacture wherein nanoscale porosity is not disclosed as imparting significant, distinctive, non-nominal, noteworthy, or unique catalytic or sorbent properties other than derived from the mere difference in surface area associated with nanoscale porosity.

514, Drug, Bio-Affecting and Body Treating Compositions, appropriate subclasses, particularly subclass 1.29 for radionuclide-containing colloidal particulate (e.g., microcapsule, micro-sphere, micro-aggregate, etc.) compositions.

516, Colloid Systems and Wetting Agents; Subcombinations Thereof; Processes of Making, Stabilizing, Breaking, or Inhibiting, appropriate subclasses for colloid systems (also called colloid dispersions or colloid suspensions, including aerosols, smokes, fogs, liquid foams, emulsions, sols, gels, coagulates, or pastes, etc.), having nanosized dispersed phase.

SECTION III - GLOSSARY:

2DEG (Two-Dimensional Electron Gas)
State of electrons in quantum well.

Artificial Atom
A quantum dot that confines a certain number or electrons producing an electron waveform structure quantum which is mechanically analogous to an atom. Alternately used to describe hollow spherical fullerene, such as buckyballs filled with a dopant.

Atomic Force Microscope (AFM)
Instrument with a nanosized tip that manipulates or detects based upon a separation dependency force between the tip and the object being manipulated or detected.

Biomimetics or Biomimicry
Nanotechnology designed to mimic biological structure/processes.

Bionanotechnology (nanobiotechnology)
A branch of nanotechnology that uses biological structures, such as proteins, ATPs, DNA, etc., as building blocks of nanoscale devices. It is sometimes called "wet-dry"technology, wherein the term "wet" pertains to biological components and "dry" refers to engineered, inorganic nanoparticles.

Bose-Einstein Condensate
A state of matter occurring in certain materials at low temperature wherein particles behaving under Fermi-Dirac statistics (such as electrons) behave like particles under Bose-Einstein statistics (such as photons). It also occurs in superconducting materials.

Bose-Einstein Statistics
A statistical distribution of boson particles, such as photons (light particles), etc., occurring between energy states.

Bottom-up manufacturing
Manufacturing that starts with atomic or molecular particles and builds up. The term is often contrasted with top-down manufacturing employing etching, deposition, evaporation, etc. associated with traditional semiconductor processes in which processing involves bulk addition or removal steps.

Brownian motion
Stochastic motion of a particle suspended in a surrounding gas or liquid comprised of other particles, molecules, or atoms, which is in thermodynamic equilibrium.

Buckminsterfullerene or Buckyball
Soccer-ball-shaped form of fullerene (C_{60}.).

Chemical Force Microscope
Scanning probe microscope with a chemically functionalized tip.

De Broglie wavelength
Wavelength of a particle under quantum mechanical conditions wherein the particle acts as a wave. Calculated by a ratio of Planck's constant to the particle's momentum.

Dendrimer
Artificially manufactured molecule, such as a synthesized polymer.

Density Functional Theory (DFT)
Theory explaining and calculating the electronic structure of molecules and solids.

Dip Pen Nanolithography
Method of fabrication utilizing a scanning probe tip to draw nanostructures on surfaces.

Fermi-Dirac Statistics
Statistical distribution of fermionic particles, such as electrons between energy states.

Fullerene
Any of various cage-like, hollow molecules composed of hexagonal and pentagonal groups of atoms, and especially those formed from carbon, that constitute the third form of carbon after diamond and graphite. Alternately, a class of cage-like carbon compounds composed of fused, pentagonal, or hexagonal sp^2 carbon rings.

Fulleride
Fullerene doped with alkali metal.

Graetzel Cell
Photovoltaic cell that uses nanoscale titanium dioxide and organic dye to obtain electrical current from incident light.

Graphene
Two-dimensional sheet form of fullerene.

Langmuir-Blodgett film
Film of surfactant molecules on a liquid surface forming regular stacks (a multilayer) or can be only one molecule thick (a monolayer); may also be formed on solid surfaces.

Magnetic Force Microscope
Scanning probe microscope in which a magnetic force causes the tip to move.

Maxwell-Boltzmann statistics
Statistical distribution of classical (nonquantum) particles, such as molecules in a gas, etc., between energy states.

MEMS (Microelectromechanical Systems)
Systems including components from 1-100 microns in size with a movable member and an electrical input and/or output to the movable member. Refers to scanning probes and other devices interfacing with the nanoscale. Differentiated from nanotechnology not just in size but also via top-down versus bottom-up manufacturing approach.

Moiety
A component part of a complex molecule.

Molecular Assembler or Nanoassembler or Assembler
Theoretical conception of a molecular machine capable of building other molecular structures.

Molecular Electronics or Moletronics
Electronic devices based on components consisting of individual molecules.

Molecular Nanotechnology
Broadly refers to nanotechnology involving molecules. (Drexlerian) Sometimes used to distinguish nanotechnology employing theoretical molecular assemblers from other forms of nanotechnology.

MWNT (Multi-walled Nanotube)
Formed of multiple layers of graphene wrapped in cylindrical form.

Nanocluster
Cluster of atoms or molecules whose characteristic dimensions are a few nanometers; sometimes synonymous with nanocrystal or denoting structures smaller than nanocrystals.

Nanocomposite
Composite structure whose characteristic dimensions are found at the nanoscale.

Nanocrystal
Nanoscopic particle containing a few hundred to a few tens of thousands of atoms, and arranged in an orderly, crystalline structure;often refers to metallic nanoparticles.

Nanopore
Pore of nanometer dimensions.

Nanorod
Nanostructures shaped like long sticks or dowels with a diameter in the nanoscale but having a length that is very much longer.

Nanotube
A fullerene molecule having a cylindrical or toroidal shape.

Nanotweezers
An element used to pick up and place individual nanosized particles,usually including two opposing nanosized elements, such as nanotubes, that pick and place the nanosized particles.

Nanowire
Electrically conductive nanorod. Alternatively, a wire with a diameter of nanometer dimensions.

Nanowhisker
Often synonymous with nanorod, nanowire, or nanotube.

Near Field Scanning Optical Microscope
Scanning probe microscope that analyzes an object by recording light intensity focused through a pipette in the tip and scanned across the object at a distance less than a wavelength of the light.

Polymer
Extended molecule made by bonding together subunits called monomers. Examples include polystyrene, polyethylene, and protein (natural polymer of amino acids).

Protein Folding
Process by which a protein assumes its functional shape. Protein folding problem involves the prediction of the protein three-dimensional shape based on its amino acid sequence.

Quantum Cell
A structure comprising four quantum dots arranged in a square, with two diagonally opposed dots containing electron charges. One diagonal containing charges is arbitrarily defined as representing a value of "1", the other as "0". In a five-dot cell, the fifth, central dot contains no charge.

Quantum Computing
A computing scheme dependent upon wavelike properties of elementary particles.

Quantum Dot
Broadly, a structure that promotes confinement of electron(s)/hole(s) in three dimensions. Alternately, a location capable of containing a single electron charge. Synonymous with single electron transistor, qubit, and quantum bit.

Quantum Entanglement
The process of combining two separate pieces of information so that they can be treated as a single entity; a correlation between quantum states (e.g., spin, polarization, etc.) of two or more particles.

Quantum Tunneling
Effect of transferring of particles through a potential barrier larger than the particles total energy that occurs based upon the barrier thickness and the difference between the potential barrier energy and the particle energy.

Quantum Uncertainty Principle
Principle stating that the position of a particle and its momentum, or alternatively, energy of the particle and time of measurement, cannot be simultaneously measured with arbitrary precision. Noted to not be a significant factor at length scales above the level of an atom.

Quantum Well
Broadly, a structure that promotes electron or hole confinement in one dimension so that the electron or hole can only propagate with two degrees of freedom. With respect to semiconductor physics, a semiconductor heterostructure utilizing a narrow bandgap semiconductor sandwiched between two layers of a larger bandgap semiconductor. Alternately, a potential well that confines particles within a planar region wherein the width of the region is on the order of the De Broglie wavelength of the particles.

Quantum Cell Wire
Wire in which information is transferred by a change in orientation of quantum cells arranged in a line as opposed to utilizing electron flow.

Quantum Wire
A structure that promotes electron or hole confinement in two dimensions so that the electron or hole can only propagate with one degree of freedom.

SAM (Self-Assembled Monolayer)
A molecule-thick, self-assembled film formed at an interface (e.g., gas/liquid, gas/solid, etc.).

Scanning Probe Microscope
Generic term for Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM) in their many forms.

Scanning Tunneling Microscope (STM)
Instrument with a nanosized tip that manipulates or detects operation based on a quantum tunneling effect generating a current between the tip and an object being manipulated or detected based upon the size of the gap between the tip and object.

Self-Assembly
Method of assembling molecules utilizing thermodynamic tendency to seek the lowest energy state for a group of molecules.

SWNT (Single Walled Nanotube)
Formed from one layer of graphene wrapped in cylindrical form.

Please send any comments or questions to

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