Nanoscience and Nanotechnology Glossary of Terms

2007

Nanoposts.com

1 GLOSSARY OF TERMS

Term	Description
AFM	atomic force microscopy/microscope
Anions	An ion consists of one or more atoms and carries a unit charge of electricity. Those that are negative ions (hydroxyl and acidic atoms or groups) are called anions (cf. cation).
Assembler	A general-purpose device for molecular manufacturing, capable of guiding chemical reactions by positioning molecules.
Atom	The smallest unit of a chemical element, about a third of a nanometre in diameter. Atoms make up molecules and solid objects.
Atomic force microscopy / microscope (AFM)	Atomic force microscopy is a technique for analysing the surface of a rigid material all the way down to the level of the atom. The atomic force microscope was invented in 1986 uses a mechanical probe to magnify surface features up to 100 000 000 times, and produces 3D images of the surface. AFM uses various forces that occur when two objects are brought within nanometres of each other. An AFM can work either when the probe is in contact with a surface, causing a repulsive force, or when it is a few nanometres away, where the force is attractive. AFM is being used to understand materials problems in many areas, including data storage, telecommunications, biomedicine, chemistry, and aerospace. AFM is derived from a related technology, called scanning tunnelling microscopy (STM). The difference is that AFM does not require the sample to conduct electricity, whereas STM does. AFM also works in regular room temperatures, while STM requires special temperature and other conditions.
Bar	A unit of pressure equal to one million (106) dynes, equivalent to 10 newtons, per square centimetre. This is approximately the pressure exerted by Earth's atmosphere at sea level.
BioMEMS	Miniaturization engineering or MEMS applied to biotechnology or medicine. In BioMEMS the number of materials involved is much larger than in a comparable electronics application. Both instruments and sensors are used in BioMEMS. Applications include: forensic science (e.g. DNA); clinical diagnostics (e.g. glucose in blood); product development (e.g. new drug); and quality control (e.g. pH of swimming pools).
Biomimetics	The concept of taking ideas from nature, operating on the nanoscale, and implementing them in a technology such as engineering, design, computing or other areas.
Bottom-up	Building organic and inorganic structures atom-by-atom, or molecule-by-molecule. Cf. top-down.
Brownian assembly	Brownian motion in a fluid brings molecules together in various position and orientations. If molecules have suitable complementary surfaces, they can bind, assembling to form a specific structure. Brownian assembly is a less paradoxical name for self-assembly.
Brownian motion	Motion of a particle in a fluid owing to thermal agitation.
Buckminsterfullerene	A sphere of sixty carbon atoms, also called a buckyball. Named after the architect Buckminster Fuller, who is famous for the geodesic dome that buckyballs resemble.
Buckyball	A popular name for Buckminsterfullerene.

CAIBE	Chemically assisted ion beam etching.
Carbon black	Carbon black is a powdered form of elemental carbon. The primary use of carbon black is in rubber products, mainly tyres and other automotive products, but also in many other rubber products such as hoses, gaskets and coated fabrics. Much smaller amounts of carbon black are used in inks and paints, plastics and in the manufacture of dry-cell batteries.
Carbon nanotubes	Two types of nanotube exist: the single-walled carbon nanotubes, so called 'buckytubes', and multilayer carbon nanotubes. Both consist of graphite carbon and typically have an internal diameter of 5nm and an external diameter of 10nm. Many applications are envisaged: space and aircraft manufacture, automobiles, and construction. Multilayer carbon nanotubes are in commercial use. Buckytubes are some way off commercial production.
CARs	Chemically amplified resists.
Catalyst	A substance that increases the rate of a chemical reaction by reducing the activation energy, but which is left unchanged by the reaction. A catalyst works by providing a convenient surface for the reaction to occur. The reacting particles gather on the catalyst surface and either collide more frequently with each other or more of the collisions result in a reaction between particles because the catalyst can lower the activation energy for the reaction.
Catenane	The latest molecular switches are created using unique molecules, called catenanes, which consist of two tiny mechanically interlocked rings, each ring composed of atoms linked in a circle. Catenanes are an improvement over rotaxane molecules. Rotaxanes are in a solution state and are much more incoherent.
Cations	An ion consists of one or more atoms and carries a unit charge of electricity. Those that are positively electrified (hydrogen and the metals) are called cations (cf. anion).
Cell	A small structural unit, surrounded by a membrane, making up living things.
Chemical vapour deposition (CVD)	A technique used to deposit coatings, where chemicals are first vaporized, and then applied using an inert carrier gas such as nitrogen.
Chromatography	The physical method of separation in which the components to be separated are distributed between two phases, one of which is stationary while the other moves in a definite direction. Chromatography is a widely used for the separation, identification, and determination of the chemical components in complex mixtures.
Complementary metal-oxide semiconductor (CMOS)	The semiconductor technology used in the transistors that are manufactured into most of today's computer microchips.
Composites	Combinations of metals, ceramics, polymers, and biological materials that allow multi-functional behaviour. One common practice is reinforcing polymers or ceramics with ceramic fibres to increase strength while retaining light weight and avoiding the brittleness of the monolithic ceramic. Materials used in the body often combine biological and structural functions (e.g., the encapsulation of drugs).
Correlated electrons	The state of matter where many electrons are strongly interacting with each other, forming the liquid-, solid-, and liquid-crystal-like state of electrons. Those electronic phases can be switched by external stimuli, which causes drastic changes in magnetic, electrical, and optical properties. Such a phase switching can be as fast as one picosecond or less.

Dendrimer	A dendrimer is an artificially manufactured or synthesized large molecule comprised of many smaller ones linked together - built up from branched units called monomers. Technically, dendrimers are a unique class of a polymer, about the size of an average protein, with a compact, tree-like molecular structure, which provides a high degree of surface functionality and versatility. The shape of dendrimers give them vast amounts of surface area, making them useful building blocks and carrier molecules at the nanoscale and they come in a variety of forms, with different physical (including optical, electrical and chemical) properties. For example, dendrimers can act as biologically active carrier molecules in drug delivery to which can be attached therapeutic agents and as scavengers of metal ions, offering the potential for environmental clean-up operations because their size allows them to be filtered out with ultra-filtration techniques.
Diode	A diode is a specialized electronic component with two electrodes called the anode and the cathode. Most diodes are made with semiconductor materials such as silicon, germanium, or selenium. Diodes can be used as rectifiers, signal limiters, voltage regulators, switches, signal modulators, signal mixers, signal demodulators, and oscillators.
Dip pen nanolithography	A direct-write soft lithography technique that is used to create nanostructures on a substrate of interest by delivering collections of molecules via capillary transport from an AFM tip to a surface.
DNA	DeoxyriboNucleic Acid. DNA is a code used within cells to form proteins.
DNA chip	A purpose built microchip used to identify mutations or alterations in a gene's DNA.
DRAM	Dynamic random access memory.
Dry nanotechnology	Derives from surface science and physical chemistry, focuses on fabrication of structures in carbon silicon, and other inorganic materials. Unlike the ‘wet’ technology, ‘dry’ techniques admit use of metals and semiconductors. The active conduction electrons of these materials make them too reactive to operate in a ‘wet’ environment, but these same electrons provide the physical properties that make ‘dry’ nanostructures promising as electronic, magnetic, and optical devices. Another objective is to develop ‘dry’ structures that possess some of the same attributes of the self-assembly that the wet ones exhibit.
EC	European Commission.
Elastomeric stamp or mould	Key element in soft lithography usually made from polydimethylsiloxane (PDMS), having patterned relief structures on its surface.
Elastomers	Cross-linked high-polymer materials with elastic behaviour.
Electronic nose	Nanotechnology used to detect odours. The task of a sensor of an electronic nose is, like that of a sensory neuron in the olfactory epithelium, to convert the contact of an odorous molecule into a detectable signal.
Electrospinning	Electrospinning uses an electrical charge to form a mat of fine (nano)fibres. Electrospinning shares characteristics of both the commercial electrospray technique and the commercial spinning of fibers.
Epitaxy	Epitaxy or epitaxial growth is the process of depositing a thin layer (0.5 to 20 microns) of single crystal material over a single crystal substrate, usually through chemical vapor deposition (CVD).

Electro scanning microscope (ESM)	Used for the study of surface morphology and the determination of the thickness of MBE grown films.
Embossing	Creation of a 3D design or image on paper or other material.
Enzymes	Molecular machines found in nature made of protein, which can catalyse (speed up) chemical reactions.
ESM	Electro scanning microscope.
EU	European Union.
Extracellular matrix (ECM)	A complex structural entity surrounding and supporting cells that are found within mammalian tissues. The ECM is often referred to as the connective tissue. The ECM is composed of three major classes of biomolecules: structural proteins (collagen and elastin) specialized proteins (e.g. fibrillin, fibronectin, and laminin); and proteoglycans: (composed of a protein core to which is attached long chains of repeating disaccharide units termed of glycosaminoglycans (GAGs) forming extremely complex high molecular weight components of the ECM).
FCVA	Filtered cathodic vacuum arc.
Ferrofluids	Also known as magnetic liquids, they are re stable colloidal suspensions of single domain particles of ferromagnetic or ferrimagnetic materials. They have existed for more than sixty years but the concentrated fluids that are used today first appeared in 1965. Ferrofluids consist of very small magnetic particles held in suspension in a carrier liquid by a surface active layer. The carrier liquid is selected to meet the particular application and can be a hydrocarbon, ester, perfluoropolyether, water, etc.
FIB	Focussed ion beam.
"Extreme" nanotechnology	Builds structures from the 'bottom up'. It encompasses atomic and molecular manipulation and self-assembly, including single electron devices using electron tunnel junctions and quantum computing and cryptography.[1]
Fullerene	A fullerene is a pure carbon molecule composed of at least 60 atoms of carbon. They are cage-like structures of carbon atoms; the most abundant form produced is Buckminster-fullerene (C60), with sixty carbon atoms arranged in a spherical structure. Because a fullerene takes a shape similar to a soccer ball or a geodesic dome, it is sometimes referred to as a buckyball after the inventor of the geodesic dome, Buckminster Fuller, for whom the fullerene is more formally named.
Functional nanotechnology	Applications in which nanostructures are used to produce improved optical, electronic or magnetic properties. Includes nanoelectronics based on quantum effects.
Gbps	Billions of bits per second. A measure of bandwidth on a digital data transmission medium such as optical fibre.
Genomics	The study of the full complement of genes that make up an organism.
HRTEM	High resolution transmission electron microscopy.

[1] EPSRC Theme Day, http://www.epsrc.ac.uk/CMSWeb/Downloads/Other/NanotechnologyThemeday2005.pdf

Ion	An atom or group of atoms in which the number of electrons is different from the number of protons. If the number of electrons is less than the number of protons, the particle is a positive ion, also called a cation. If the number of electrons is greater than the number of protons, the particle is a negative ion, also called an anion.
Langmuir-Blodgett	The name of a nanofabrication technique used to create ultrathin films (monolayers and isolated molecular layers), the end result of which is called a Langmuir-Blodgett film.
LCD	Liquid crystal display.
Liquid crystal display (LCD)	Technology used for displays in notebook and other smaller computers. LCDs allow displays to be much thinner than cathode ray tube technology. LCDs consume much less power because they work on the principle of blocking light rather than emitting it.
LED	Light emitting diode.
Light emitting diode (LED)	A semiconductor device that emits visible light when an electric current passes through it. The light is not particularly bright, but in most LEDs it is monochromatic, occurring at a single wavelength. The output from an LED can range from red (at a wavelength of ~700nm) to blue-violet (~400nm).
Magnetorheological fluids	Magnetorheological fluids are stable suspensions of magnetically polarisable micron sized particles suspended in a low volatility carrier fluid, usually a synthetic hydrocarbon.
Magnetron sputtering	Magnetron sputtering involves the creation of a plasma by the application of a large DC potential between two parallel plates. A static magnetic field is applied near a sputtering target and confines the plasma to the vicinity of the target. Ions from the high-density plasma sputter material, predominantly in the form of neutral atoms, from the target onto a substrate.
MBE	Molecular beam epitaxy.
MEMS	MicroElectroMechanical Systems.
Mesoporous	A mesoporous material is a material containing pores with diameters between 2 and 50 nm. They have huge surface areas, providing a vast number of sites where sorption processes can occur. These materials have numerous applications in catalysis, separation and many other fields.
MicroElectroMechanical Systems (MEMS)	Technology used to integrate various electro-mechanical functions onto integrated circuits. A typical MEMS device combines a sensor and logic to perform a monitoring function. Examples include sensing devices used to control the deployment of airbags in cars and switching devices used in optical telecommunications cables.
Microfluidics	Liquid streams used to separate, control, or analyze at the nanoscale.
Molecular beam epitaxy (MBE)	Process used to make compound (multi-layer) semiconductors. Consists of depositing alternating layers of materials, layer by layer, one type after another (such as the semiconductors gallium arsenide and aluminium gallium arsenide).
Molecular computing	Molecular computing could replace silicon-based computing by the end of the decade.
Molecular electronics	Any system with atomically precise electronic devices of nanometre dimensions, especially if made of discrete molecular parts rather than the continuous materials found in today's semiconductor devices.

Molecular machines	Molecular machines are proteins that convert (electro)chemical energy generated across a membrane into external mechanical work. They are responsible for a wide variety of functions from muscle contraction to cell locomotion, copying and processing DNA, movement of chromosomes, cellular division, movement of neurotransmitter-containing vesicles, and production of ATP etc.
Molecular motors	The mechanical properties of molecular motors can be thought of in terms of rectifying thermal ratchets and impedance matching lever systems (that couple enzyme-active sites to external loads). For many of the systems it is now possible to reconstitute their function using purified proteins and to observe and measure the forces and movements that they produce during a single chemical cycle. In other words, the mechanochemical processes at the level of a single molecule can be measured. Furthermore, 'man-made' molecular motors are being developed based either on hybrid constructions of existing biological motors (rotary and linear) or made from man-made materials but using molecular-motor design principles.
Molecular-scale manufacturing	Manufacturing using molecular machinery, giving molecule-by-molecule control of products and by-products via positional chemical synthesis.
Molecular switch	A molecular switch is a logic gate, a necessary computing component in molecular computing used to represent the binary language of digital computing. Molecular switches would be many times cheaper than traditional solid-state devices, and would allow for continued miniaturization and increases in power that silicon-based components would never be able to reach.
Molecular wire	A quasi-one-dimensional molecule that can transport charge carriers (electrons or holes) between its ends.
Molecule	Group of atoms held together by chemical bonds, a molecule is the typical unit manipulated by nanotechnology.
Mesoporous	Mesoporous materials are porous materials with regularly arranged, uniform mesopores (2-50nm in diameter). Their large surface areas make them useful as adsorbents or catalysts.
Modelling	Aims to provide the quantitative understanding of physical systems and processes. It ranges from offering a framework of understanding to quantitative predictions based on state of the art calculations. At the nanoscale, modelling can analyse and predict properties of systems, processes and other phenomena in ways that complement experiment.
Molecular (including bio-molecular) nanotechnology	Molecular sensing and molecular recognition. Much of the research is at the interface between the life and physical sciences. This includes: lab-on-a-chip and smart sensors for medical and environmental monitoring and diagnosis; tissue repair; targeted drug delivery. At the single cell level: gene therapy and screening; drug testing; design of nanomachines; replacement structures.
Moore's Law	The observation made in 1965 by Gordon Moore, co-founder of Intel, that the number of transistors per square inch on integrated circuits had doubled every year since the integrated circuit was invented. Moore predicted that this trend would continue for the foreseeable future.
MWNT	Multi-walled nanotubes.
nano	A prefix meaning one billionth (1/1 000 000 000).

Nanobiotechnology	Nanotechnology integrated into the biology realm, in particular into molecular biology and cell biology. At the interface between biotechnology and nanotechnology, nanobiotechnologists carry out research on the phenomena of self-assembly or self-organisation of biomolecules such as cell membranes or virus particles, in order to adapt these principles to the technical production of nanostructures.
Nanocomposites	Polymer/inorganic nanocomposites are composed of two or more physically distinct components (e.g. metals, ceramics, polymers and biological materials) with one or more average dimensions smaller than 100nm. From the structural point of view, the role of inorganic filler, usually as particles or fibres, is to provide intrinsic strength and stiffness while the polymer matrix can adhere to and bind the inorganic component so that forces applied to the composite are transmitted evenly to the filler. The material's properties, e.g. hardness, transparency, porosity are altered.
Nanocrystal	Molecular-sized solids formed with a repeating, 3D pattern of atoms or molecules with an equal distance between each part. Nanocrystals are aggregates of anywhere from a few hundred to tens of thousands of atoms that combine into a crystalline form of matter known as a 'cluster'. Typically around 10nm in diameter, nanocrystals are larger than molecules but smaller than bulk solids and therefore frequently exhibit physical and chemical properties somewhere in-between. Nanocrystals are believed to have potential in optical electronics because of their ability to change the wavelength of light.
Nano-electromechanical systems (NEMS)	Devices and machines, an extension of present-day micro machines and micro actuators into the nano domain. Protein motors, capable of linear or rotary motion. DNA and active devices such as nanowires, switches, motors and tweezers.
Nanoelectronics	Electronics on a nanometre scale, whether made by current techniques or nanotechnology; includes both molecular electronics and nanoscale devices resembling today's semiconductor devices.
Nanofabrication	Using 'top down' techniques for the manufacture of materials with dimensions less than 100 nm, involving lithographic techniques beyond the optical domain using electron beam and X-ray lithography. Advanced manufacturing processes and instrumentation for manipulation at the nanoscale, including scanning probe techniques, focused ion beam technology and nanomanipulators.
Nanofibres	Hollow and solid carbon fibres with lengths on the order of a few microns and widths varying from tens of nanometres to around 200nm.
Nanofiltration	Nanofiltration is a pressure-driven membrane process that can separate molecules in the 200-1000 Dalton range. It can be used either to allow valuable molecules to permeate through the membrane (retaining impurities or unwanted materials) or to retain valuable materials (product, catalyst, etc.) whilst allowing the other components of the fluid to permeate through the membrane.
Nanofluidics	Controlling nanoscale amounts of fluids.
Nanolithography	Nanolithography is the art and science of etching, writing, or printing at the microscopic level, where the dimensions of characters are on the order of nanometres. This includes various methods of modifying semiconductor chips at the atomic level for the purpose of fabricating integrated circuits (ICs). Instruments used in nanolithography include the scanning tunnelling microscope (STM) and the atomic force microscope (AFM). Both allow surface viewing in fine

	detail without necessarily modifying it. Either the STM or the AFM can be used to etch, write, or print on a surface in single-atom dimensions.
Nanomanipulation	The process of manipulating items at an atomic or molecular scale in order to produce precise structures.
Nanometre	One billionth of a metre / 10-9m, / a millionth of a millimetre.
Nanometrology	Precise measurement below 100nm and development of measurement techniques.
Nanophotonics	Nanophotonics is the nano-engineering of light-matter interactions so that new phenomena of physics can be utilized to develop novel optoelectronics devices which can be well beyond the capability of the conventional photonics and electronics.
Nanopores	Nanoscopic pores found in purpose-built filters, sensors, or diffraction gratings.
Nanoscale	Between 0.1-100nm.
Nano-science	Nanoscience is concerned with obtaining an understanding of fundamental phenomena, properties and functions at the nano-scale, that are not scalable outside the nanometre domain.
Nanosheets	Nanosheets are obtained by delaminating a layered host material into its elementary sheets through soft-chemical procedures.
Nanospring	A nanowire wrapped into a helix.
Nanostructured materials	Where grain and composite size is less than 100nm, offering potential for stronger, more wear and corrosion resistant materials. These include carbon nanotubes, biomaterials, thin films, anticorrosion coatings, colloids and nanopowders.
Nanotechnology	Nanotechnology is the term used to cover the design, construction and utilization of functional structures with at least one characteristic dimension measured in nanometres. Such materials and systems can be designed to exhibit novel and significantly improved physical, chemical and biological properties, phenomena and processes as a result of the limited size of their constituent particles or molecules. The reason for such interesting and very useful behaviour is that when characteristic structural features are intermediate in extent between isolated atoms and bulk macroscopic materials; i.e., in the range of about 10-9m to 10-7 m (1 to 100 nm), the objects may display physical attributes substantially different from those displayed by either atoms or bulk materials. Ultimately this can lead to new technological opportunities as well as new challenges.
Nanotube	Nanotubes are a material with remarkable tensile strength. Nanotube-based materials are anticipated to become 50-100 times stronger than steel at one-sixth of the weight. Nanotubes are a one-dimensional fullerene (a convex cage of atoms with only hexagonal and/or pentagonal faces) with a cylindrical shape.
Nanowires	One-dimensional structures, with unique electrical and optical properties, that are used as building blocks in nanoscale devices.
NEMS	NanoElectroMechanical Systems.
nm	Nanometre.
organic LED	An LED made from carbon-based molecules, not semiconductors.

Photolithography	The technique used to produce the silicon chips that make up modern-day computers. The traditional process involves shining light through a mask onto a photosensitive polymer (photoresist) on a silicon surface, then subsequently removing the exposed areas.
Photonics	Electronics using light (photons) instead of electrons to manage data.
Physical vapour deposition (PVD)	Along with CVD, a group of surface treatments applied on tools and machine elements. In the area of machining and tooling PVD coatings are widely used to increase the life and productivity of production tools and therefore reducing manufacturing costs.
Polymers	Tiny molecules strung in long repeating chains form polymers. DNA is a polymer as are the proteins and starches in foods and the tyres on bikes and cars. Polymers are generally recyclable. In nanotechnology examples include organic-based materials that emit light when an electric current is applied to them and vica versa, and use in computing and energy conversion.
Proteomics	Refers to all the proteins expressed by a genome, and thus proteomics involves the identification of proteins in the body and the determination of their role in physiological and pathophysiological functions.
PVD	Physical vapour deposition.
Quantum computer	A computer that takes advantage of quantum mechanical properties such as superposition and entanglement resulting from nanoscale, molecular, atomic and subatomic components.
Quantum dot	Fluorescent nanoparticles that are invisible until ‘lit up’ by ultraviolet light. A nanoscale crystalline structure that can transform the colour of light. The quantum dot is considered to have greater flexibility than other fluorescent materials, which makes it suited to use in building nanoscale computing applications where light is used to process information. They are made from a variety of different compounds, such as cadmium selenide that produce different colours of light. Quantum dots have potential applications in telecommunications and optics.
Quantum wire	Another form of quantum dot, but unlike the single-dimension ‘dot’, a quantum wire is confined only in two dimensions - that is it has ‘length’, and allows the electrons to propagate in a ‘particle-like’ fashion. Constructed typically on a semiconductor base.
Reactive ion etching (RIE)	This is a key aspect in integrated circuit engineering and serves to transfer a pre-defined pattern into the required substrate anisotropically through an interplay between the chemical reactive radicals and physical ion bombardment in the plasma. In the semiconductor industry, this technology is used in the fabrication of advanced devices for high-speed electronics and optoelectronics.
Scanning electron microscopy (SEM)	Utilized in medical science and biology and in such diverse fields as materials development, metallic materials, ceramics, and semiconductors. SEM involves the manipulation of an e-beam that is scanned across the surface of specially prepared specimens to obtain a greatly enlarged, high-resolution image of the specimen's exposed structure. Specimens are scanned with a very fine probe (‘tip’) and the strength of interaction between the tip and surface us monitored. The specimen can be observed whole for assessing external structure or freeze-fracture techniques can be used to image internal structures. STM led to the development of a related technology, atomic force microscopy.
Scanning force	A SFM works by detecting the vertical position of a probe while horizontally scanning the

microscope (SFM)	probe or the sample relative to the other. The probe is in physical contact with the sample and its vertical position is detected by detecting the position of a reflected laser beam with a photo diode that consists of two or four segments. scanning near field optical microscopy (SNOM) The operational principle behind near-field optical imaging involves illuminating a specimen through a sub-wavelength sized aperture whilst keeping the specimen within the near-field regime of the source. Broadly speaking, if the aperture-specimen separation is kept roughly less than half the diameter of the aperture, the source does not have the opportunity to diffract before it interacts with the sample and the resolution of the system is determined by the aperture diameter as oppose to the wavelength of light used. An image is built up by raster-scanning the aperture across the sample and recording the optical response of the specimen through a conventional far-field microscope objective. (As opposed to conventional optical microscopy or 'far-field optical microscopy').
Scanning probe microscope (SPM)	In SPM a nanoscopic probe is maintained at a constant height over a bed of atoms. The probe can be positioned so close to individual atoms that the electrons of the probe-tip and atom begin to interact. These interactions can be strong enough to 'lift' the atom and move it to another place.
Scanning Probe Microscopy	Scanning probe microscopy (SPM) has revolutionised our ability to characterise the surface morphologies of complex and difficult materials. Since the earliest scanning tunnelling microscopy images revealed the arrangements of atoms in semiconductor surfaces, the capability of SPM for the visualisation of surface structures has been clear
Scanning tunnelling microscope (STM)	A device that obtains images of the atoms on the surfaces of materials - important for understanding the topographical and electrical properties of materials and the behaviour of microelectronic devices. The STM is not an optical microscope; instead it works by detecting electrical forces with a probe that tapers down to a point only a single atom across. The probe in the STM sweeps across the surface of which an image is to be obtained. The electron shells, or clouds, surrounding the atoms on the surface produce irregularities that are detected by the probe and mapped by a computer into an image. Because of the quantum mechanical effect called 'tunnelling' electrons can hop between the tip and the surface. The resolution of the image is in the order of 1nm or less.
SEM	Scanning electron microscope.
Semiconductor	A substance, usually a solid chemical element or compound, that can conduct electricity under some conditions but not others, making it a good medium for the control of electrical current. Its conductance varies depending on the current or voltage applied to a control electrode, or on the intensity of irradiation by infrared (IR), visible light, ultraviolet (UV), or X rays.
SFM	Scanning force microscope.
Sol-gels	Sol–gel methods involve a set of chemical reactions which irreversibly convert a homogeneous solution of molecular reactant precursors (a sol) into an infinite molecular weight three-dimensional polymer (a gel) forming an elastic solid filling the same volume as the solution. Typically this involves a hydrolysis reaction followed by condensation polymerization.

Spintronics	Electronics that exploits the spin of an electron in some way, rather than just its charge.
Self-assembling monolayers (SAMs)	Organic or inorganic substances spontaneously form a layer one molecule thick on a surface. Additional layers can be added, leading to laminates where each layer is just one molecule in depth. There is a wide range of applications, based on properties ranging from being chemically active to being wear resistant.
Self-assembly	Refers to the use in materials processing or fabrication of the tendency of some materials to organize themselves into ordered arrays (e.g., colloidal suspensions). This provides a means to achieve structured materials "from the bottom up" as opposed to using manufacturing or fabrication methods such as lithography, which is limited by the measurement and instrumentation capabilities of the day. For example, organic polymers have been tagged with dye molecules to form arrays with lattice spacing in the visible optical wavelength range and that can be changed through chemical means. This provides a material that fluoresces and changes colour to indicate the presence of chemical species.
Smart materials	Reactive materials that combine sensors and actuators, and possibly computers, to enable a response to environmental conditions and changes to those conditions. Applications include uniforms or aircraft skins fabricated from radar-absorbing materials that incorporate avionic links and the ability to modify shape in response to airflow.
SNOM	Scanning near field optical microscopy.
SPM	Scanning probe microscope.
STM	Scanning tunnelling microscope.
Superparamagnetic	Superparamagnetism is a phenomenon by which magnetic materials may exhibit a behavior similar to paramagnetism even when at temperatures below the Curie or the Néel temperature. This is a small length-scale phenomena, where the energy required to change the direction of the magnetic moment of a particle is comparable to the ambient thermal energy. At this point, the rate at which the particles will randomly reverse direction becomes significant.
SWNT	Single walled nanotubes.
Thin films	Thin films are atomically engineered layers of a wide variety of materials including metals, insulators and semiconductors. The major applications of thin films are in modification of the surface properties of solids. Individual films may be electrically conductive or non-conducting, hard or soft, thermally conducting or insulating, optically transparent, or opaque. A thin film coating can transform the electrical, mechanical and/or optical properties of a solid base material in a cost-effective way. Common examples are scratch-resistant coatings for spectacles, anti-reflection coatings for lenses, transparent conducting coatings for flat-panel displays, and low-friction coatings for bearings. Hard coatings can significantly enhance the lifetime of cutting, drilling, and forming tools. Oxygen and moisture barrier films are in widespread use in the packaging of foodstuffs, contributing to the long shelf life of many convenience foods. Thin film coatings also have unique properties that may be exploited in the polarization, reflection, transmission and absorption of light. Complex coatings can be used to provide eye-protection from lasers without significant reduction in overall transmission and other high-performance films are in use for the multiplexing of telecommunication laser signals. Other inherent properties of thin films are used in microelectronics, magnetic

	recording and optical recording media.
Tomography	Imaging by sections or sectioning
Top-down	Refers to making nanoscale structures by machining and etching techniques. cf. bottom-up.
Tribology	The science and technology of friction, lubrication, and wear, derived from the Greek tribo meaning "I rub".
Wet nanotechnology	The study of biological systems that exist primarily in a water environment. The functional nanometre-scale structures of interest here are genetic material, membranes, enzymes and other cellular components. The success of this nanotechnology is amply demonstrated by the existence of living organisms whose form, function, and evolution are governed by the interactions of nanometre-scale structures.
Zeolite	Any one of a family of hydrous aluminum silicate minerals, whose molecules enclose cations of sodium, potassium, calcium, strontium, or barium, or a corresponding synthetic compound, used chiefly as molecular filters and ion-exchange agents. Zeolite nanocrystals can act as hosts for supramolecular organization of molecules, complexes and clusters, thus encouraging the design of precise functionalities. The main role of the zeolite framework is to provide the desired geometrical properties for arranging and stabilizing the incorporated species.