Nanotechnology

Lecture 2

History and Future of Nanotechnology

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Introduction

Nanoparticles and structures have been used by humans in fourth century AD, by the Roman, which demonstrated one of the most interesting examples of nanotechnology in the ancient world. The Lycurgus cup, from the British Museum collection, represents one of the most outstanding achievements in nanotechnology ancient glass industry. The cup is also a very rare example of a complete Roman cage-cup, or diatretum, where the glass has been painstakingly cut and ground back to leave only a decorative "cage" at the original surface level. Many parts of the cage have been completely undercut. Most cage-cups have a cage with a geometric abstract design, but here there is a composition with figures, showing the mythical King Lycurgus, who (depending on the version) tried to kill Ambrosia, a follower of the god Dionysus (Bacchus to the Romans). She was transformed into a vine that twined around the enraged king and restrained him, eventually killing him. Dionysus and two followers are shown taunting the king. The cup is the "only well-preserved figural example" of a cage cup. The dichroic effect is achieved by making the glass with tiny proportions of nanoparticles of gold and silver dispersed in colloidal form throughout the glass material. The process used remains unclear, and it is likely that it was not well understood or controlled by the makers, and was probably discovered by accidental "contamination" with minutely ground gold and silver dust. The glass-makers may not even have known that gold was involved, as the quantities involved are so tiny; they may have come from a small proportion of gold in any silver added (most Roman silver contains small proportions of gold), or from traces of gold or gold leaf left by accident in the workshop, as residue on tools, or from other work. The very few other surviving fragments of Roman dichroic glass vary considerably in their two colours. The Lycurgus cup is recognized as one of the oldest synthetic nanomaterials. A similar effect is seen in late medieval church windows, shining a luminous red and yellow colors due to the fusion of Au and Ag nanoparticles into the glass. Figure below shows an example of the effect of these nanoparticles with different sizes to the stained glass windows.

The main features and characteristics of Lycurgus cup can be summarized as follows:

▪ Lycurgus cup is the oldest famous example of dichroic glass. Dichroic glass describes two different types of glass

▪ It is color changes with changing the incidence angle of light on the cup.

▪ It is color changes in certain lighting conditions. This means that the Cup have two different colors ▪ The glass appears green in direct light, and red-purple when light shines through the glass

▪ In 1990, the scientists analyzed the cup using a transmission electron microscopy (TEM) to explain the phenomenon of dichroism. The observed dichroism (two colors) is due to the presence of nanoparticles with 50–100 nm in diameter .

▪ X-ray analysis showed that these nanoparticles are silver-gold (Ag-Au) alloy, with a ratio of Ag:Au of about 7:3, containing in addition about 10% copper (Cu) dispersed in a glass matrix.

▪ The Au nanoparticles produce a red color as result of light absorption (~520 nm).

▪ The red-purple color is due to the absorption by the bigger particles while the green color is attributed to the light scattering by colloidal dispersions of Ag nanoparticles with a size > 40 nm.

The Lycurgus cup. The glass appears green in reflected light (A) and red-purple in transmitted light (B)

How were the Lycurgus cup manufactured?

▪ The process used remains unclear, and it is likely that it was not well understood or controlled by the makers ,

▪ It was probably discovered by accidental "contamination" with minutely ground gold and silver powder .

▪ The glass-makers may not even have known that gold was found, as the quantities found are so small

▪ They may have come from a small proportion of gold in any silver added (most Roman silver contains small proportions of gold), or from traces of gold or gold leaf left by accident in the workshop, as residue on tools, or from other work. The very few other surviving fragments of Roman dichroic glass vary considerably in their two colors.

History of Nanotechnology

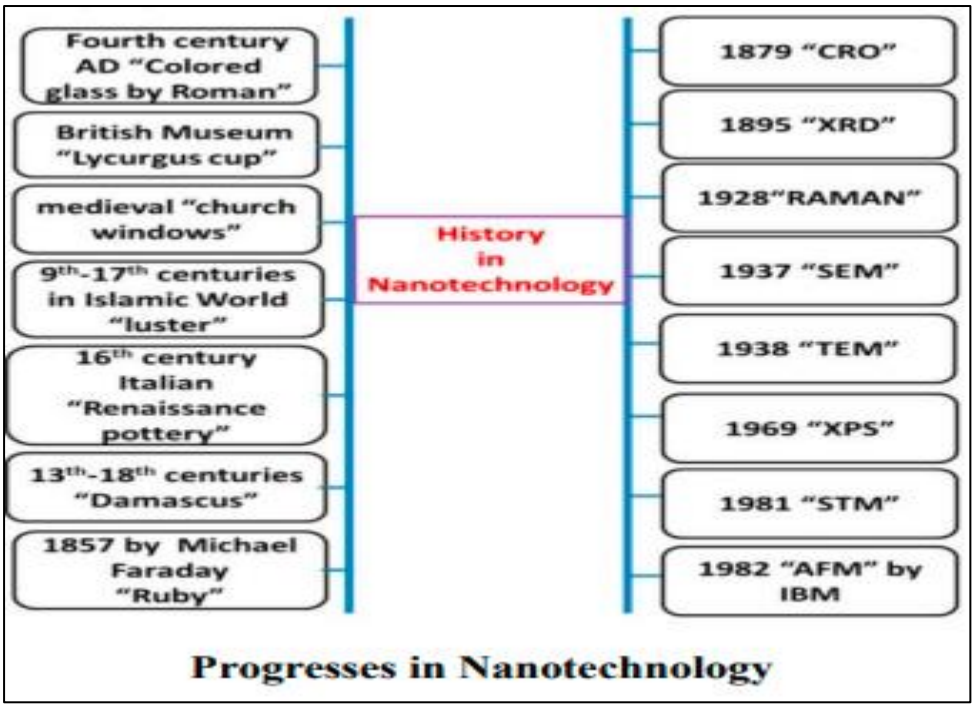
The most important events related to nanotechnology can be summarized as follows:

▪ During the 9th–17th centuries, ceramic glazes used in the Islamic world, and later in Europe contained Ag or Cu or other nanoparticles.

▪ The Italians also employed nanoparticles in Glass industry during 16th century.

▪ They were influenced by Ottoman techniques: during the 13th–18th centuries, to produce "Damascus" saber , cementite nanowires and carbon nanotubes were used to provide strong, resilience, and the ability to hold a keen edge. These colors and material properties were produced intentionally for hundreds of years. Medieval artists and forgers, however, did not know the cause of these surprising effects.

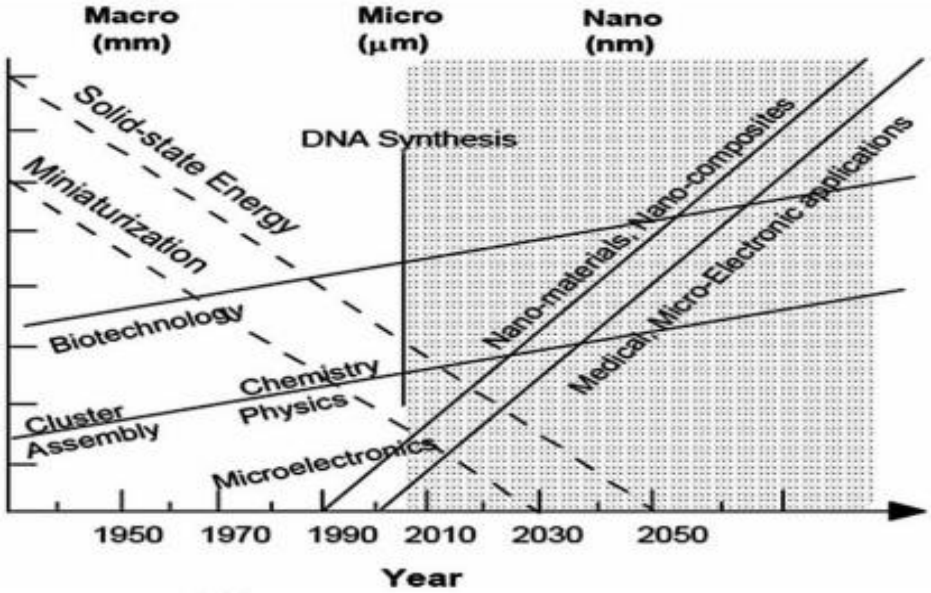
▪ In 1857, Michael Faraday studied the preparation and properties of "Ruby" gold. Their unique optical and electronic properties make them some of the most interesting nanoparticles. Faraday demonstrated how gold nanoparticles produce different colored solutions under certain lighting conditions. The progression in nanotechnology due to the blessings of nanoscience are summarized in the Figure below.



Progresses in Nanotechnology

Almost 15 years after Feynman's lecture, a Japanese scientist, Norio Taniguchi, was the first to use "nanotechnology" to describe semiconductor processes that has been occurred on the order of a nanometer. He mentioned that nanotechnology consisted of the processing, separation, consolidation, and deformation of materials by one atom or one molecule. The golden era of nanotechnology began in the 1980s when Kroto, Smalley, and Curl discovered fullerenes and Eric Drexler of Massachusetts Institute of Technology (MIT) used ideas from Feynman's "There is Plenty of Room at the Bottom" and Taniguchi's term nanotechnology in his 1986 book titled, "Engines of Creation: The Coming Era of Nanotechnology." Drexler proposed the idea of a nanoscale "assembler". Drexler's vision of nanotechnology is also called "molecular nanotechnology." The science of nanotechnology was advanced further when Iijima, another Japanese scientist, developed carbon nanotubes . The beginning of the 21st century saw an increased interest in the emerging fields of nanoscience and nanotechnology. In the United States, Feynman's stature and his concept of manipulation of matter at the atomic level played an important role in shaping national science priorities. President Bill Clinton advocated for funding of research in this emerging technology during a speech at Caltech on January 21, 2000. later, President George W. Bush signed into law the 21st Century Nanotechnology Research and Development. The legislation made nanotechnology research a national priority and created the National Technology Initiative (NNI). Today, the NNI is managed within a framework at the top of which the President's Cabinet-level National Science and Technology Council (NSTC) and its Committee on Technology. The

Committee's Subcommittee on Nanoscale Science, Engineering, and Technology (NSET) is responsible for planning, budgets, implementation, and review of the NNI and it is comprised of representatives from 20 US departments and independent agencies and commissions The idea of nanotechnology appeared for the first time by the physicist R. Feynman in the America-1959. Feynman described a process by which the ability to manipulate atoms and molecules maybe developed . The term of nanotechnology was originally defined by Norio in 1974 as follows: "Nano-technology mainly consists of the processing of separation and consolidation of materials by one atom or by one molecule."



Evolution of science and technology and the future