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QUALITY PARAMETERS IN NANOTECHNOLOGIC APPLICATIONS

Abstract: *Nanotechnology concept which has added a new dimension to our lives in recent years, is finding a place in every sector day by day. The combined effect of nanotechnology is almost equal to the industrial revolution of last 200 years and have is able to fill all developments in a few years. However this development should be taken under control. Otherwise unstoppable new structures will not ease life but will be a problem for humanity. For this purpose, the main parameters (from the start up stage of nano-technologic applications to the obtained product) should be checked. These parameters are actually not different than the adaptation of the classical quality indicators for nanotechnology applications.*

Especially it plays an important role in obtaining a uniform distribution and regarding the features of the end product in nano-technological ceramic and etc. applications. The most important problem faced in particles of that size is the accumulation they create. Another problem is the increasing friction force as size gets smaller. The friction force of a substance increases proportionally with the cube of its surface area.

Another problem is surface tension. The increasing surface tension due to increasing surface area will cause the particles to attract and stick to each other. The structures aimed to be obtained are mostly complex and especially in upwards approach, it is thermodynamically very hard for the atoms to get into that order.

Therefore in this announcement, we stated the quality parameters that will be taken into consideration in nano-technological applications and the methods for obtaining those parameters. The aim is to explain these parameters with all dimensions so that they will lead the way to the future nano-technological applications.

Keywords: *nanotechnlogy, quality, parameters*

1. Introduction

The gravity of nanotechnology is related to the fact that by working on the levels of atoms and molecules (between 1 to 100 nanometer (nm) scale), it enables the

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procurement of developed constructs and/or structures with totally new physical, chemical and biological features. Nanotechnology is rapidly being shaped as the industrial revolution of the 21^{st} century. Nanotechnology is going to affect every part of our lives starting from the food we intake, clothes we wear, drugs we take, as well as the power of our cars and houses we live in. In the long run, the effects of nanotechnology will be so much evident as the use of steam power, electricity or transistors from the past. Deeply involved in our lives-and likely to be in future as well-nanotechnology now requires to be on stage not only in manufacture level but in quality too.

The envisaged structuring will enable the building of potential materials as starting from atomic and molecular dimensions so that compared to materials formed via conventional methods, more durable and less heavier materials will be procured. By virtue of their smaller levels of defect and unique durability, they will introduce revolutionary innovations for a great number of current industrial processes. Thanks to their matchless and nonconventional qualities, they will assist in developing manufacturing methods and techniques of nano tubes, fibers and coating materials.

From a technical perspective, material qualities and operation principles of equipments are based on the conventional modeling and theories that are procured upon the hypotheses that mostly focus on dimensions larger than 100 nm. Once the critical lengths go below 100nm, conventional theories and models, most of the times, fail to explain the newly emerging qualities.

As is known, the desire to develop more durable, higher quality, more lasting and less expensive, lighter and smaller devices is a common trend dominating a large number of professions. This trend that can also be defined as miniaturization constitutes the base of many engineering works. Miniaturization has a lot more significant advantages than the physical shrinkage of the parts used. In miniaturization production there is less material, less energy, cheaper and more comfortable transportation, more functions and simplicity in use.

As of the second half of 20^{th} century, the tolerances utilized in many industries have been improved continuously and high-quality approach has been developed. The parts that we can define as micro technology products have been commonly used in automotive, electronics, communication sectors. Today however, the use of smaller technologies than micro technology-nanotechnology- is increasing ever more. By virtue of nanotechnology, new products will be developed in industry, communication technologies, health and several other branches and modern manufacturing processes and methods will undergo changes. New financial values will be created in countries investing into this technology and life qualities of societies will improve.

In this paper reflecting aforementioned deductions, the aim has been to demonstrate the kind of parameters used and the way these parameters are selected in nanotechnological applications.

2. Detecting the characteristic features in nanotechnology

In essence nanotechnology is a developed dimension of material science. That is the reason for analyzing the structures comprising quantum dimensions instead of classical dimensions of physics. Similar to industrial materials in this dimension too quality parameters, the physical, chemical and mechanical parameters within the technological definition of material are essential features. And yet this is certainly not so easy. Since the material is constructed of too tiny particles, the implementor faces harsh times during application. At this point, the quality of monitoring moves one step ahead.

In nano scale monitoring and examining surface features, mostly electron microscopes and scanning end microscopes are used. For instance in order to detect wall structure of a nanotubes, TEM: Transmission Electron Microscopy (Figure 1), to monitor the distribution and figures of nanotubes or nano particle SEM: Scanning Electron Microscopy (Figure 2) and to conduct detailed analyses and examined physical qualities, the recently developed AFM: Atomic Force Microscopy (Figure 3) are employed.

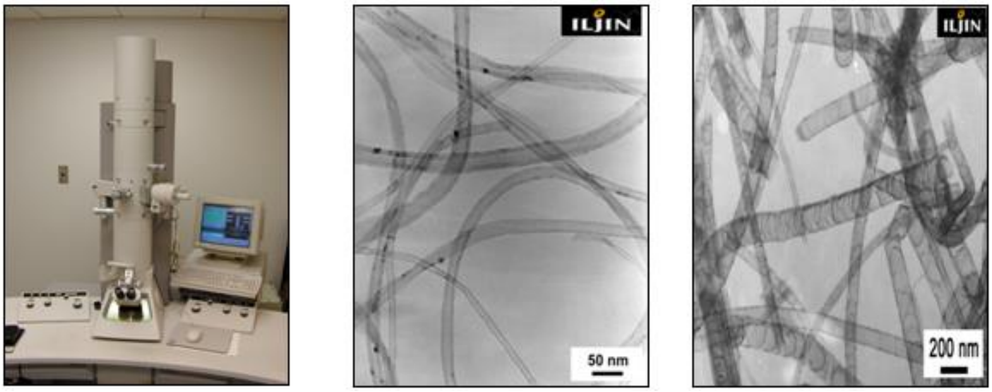

Figure 1. TEM apparatus and images

Figure 2. SEM apparatus and images

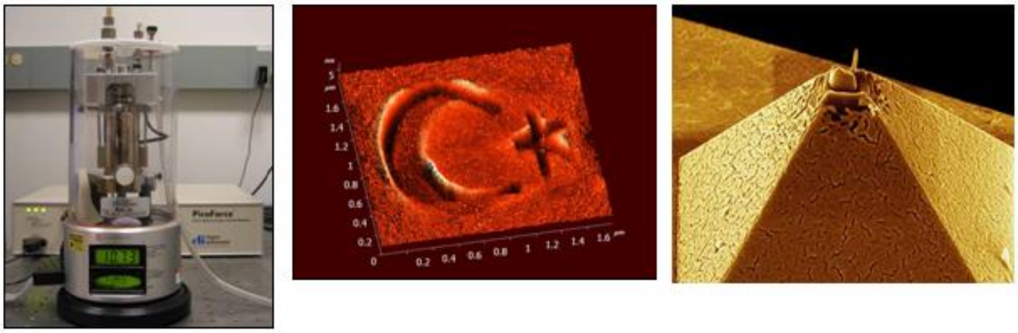

Figure 3. AFM apparatus and images

The differing functions of monitoring tools affect the image quality too. Monitoring tool must be selected according to the procedure to be followed.

Another point crucial in quality evaluations of nanotechnology applications is characterization. Characterization describes those features of composition and structure (including defects) of a material that are significant for a particular preparation, study of properties, or use, and suffice for reproduction of the material. Analysis techniques are used simply to magnify the specimen, to visualize its internal structure, and to gain knowledge as to the distribution of elements within the specimen and their interactions.

XRD and SPM are the most widely used characterization techniques to that end.

XRD technique is used to define the crystal structure of materials. XRD method provides a wide range of information on the nano structure of crystal-structured materials of which atoms or molecules have repeating arrays; these materials cover a wide scope starting from element of gold to DNA and even table salt.

Scanning probe microscopy (SPM) is a branch of microscopy that forms images of surfaces using a physical probe that scans the specimen. An image of the surface is obtained by mechanically moving the probe in a raster scan of the specimen, line by line, and recording the probe-surface interaction as a function of position. Many scanning probe microscopes can image several interactions simultaneously. The manner of using these interactions to obtain an image is generally called a mode.

The resolution varies somewhat from technique to technique, but some probe techniques reach a rather impressive atomic resolution. They owe this largely to the ability of piezoelectric actuators to execute motions with a precision and accuracy at the atomic level or better on electronic command. One could rightly call this family of technique 'piezoelectric techniques'. The other common denominator is that the data are typically obtained as a two-dimensional grid of data points, visualized in false color as a computer image.

3. Nano characterization tests

Nano-Indentation Tester is a high precision instrument for the determination of the nano mechanical properties of thin films, coatings and substrates. With a Nano-Indentation tester you can quickly determine properties such as hardness and Young's modulus on almost any type of material - soft, hard, brittle or ductile.

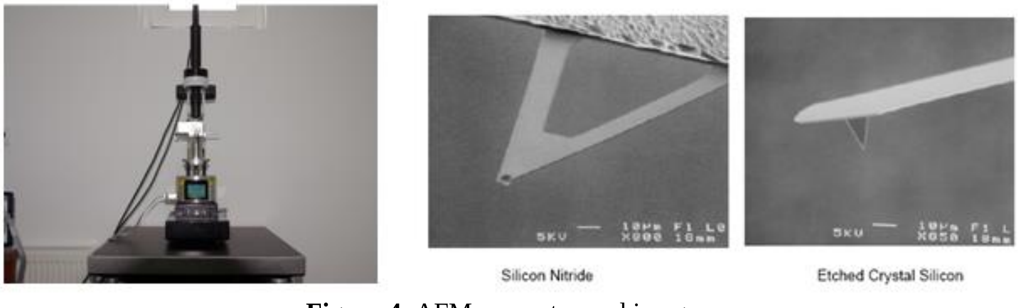

Figure 4. AFM apparatus and images

AFMs are the greatest assistants on this subject. To measure friction qualities of Nano materials a modified version of FFM: Friction Force Microscopy which has been created by adding a sensor to measure lateral forces to AFM is used.

Most contact AFM is conducted with silicon nitride tip probes. These probes are very flexible (lowspring constant) which makes them easier to use and more “forgiving” than stiffer etched crystalsilicon cantilevers. Silicon nitride probes are offered in a variety of sizes and coatings toaccommodate the sample being imaged. In tapping mode, an etched crystal silicon tip cantilever probe is oscillated near its resonant frequency .Because the cantilever is relatively stiff and oscillates at a high frequency, it possesses sufficientenergy to break free of surface tension forces. An etched silicon probe is more brittle and lessforgiving than silicon nitride (Figure 4).

Nano-Indentation Tester works on the following principle.

An indenter tip (Berkovich, Sphero-conical, Knoop or cube corner), normal to the sample surface, with a known geometry is driven into the sample by applying an increasing load up to some preset value.

The load is then gradually decreased until partial or complete relaxation of the sample has occurred. The load and displacement are recorded continuously throughout this process to produce a load displacement curve from which the nano-mechanical properties such as hardness, Young's modulus, stress-strain studies time dependant creep measurement, fracture toughness, plastic & elastic energy of the sample material can be calculated. Nano Indentation tester can be used in a mapping mode to take data automatically from a variety of locations on your sample (Table 1).

Table 1. General Applications Nano-Indentation Tester

Semiconductor Technology	**Wear Resistant Coatings**
Passivation Layers	TiN, TiC, DLC
Metallization	Cutting Tools
Bond Pads	**Pharmacological**
Mass Storage	Tablets and pills
Protective coatings on magnetic disks	Implants
Magnetic coatings on disk substrates	Biological tissue
Protective coatings on CD's	**Automotive**
Optical Components	Paints and polymers
Contact lenses	Varnishes and finishes
Eye glass lenses	Windows
Fibre Optics	**General Engineering**
Optical scratch-resistant coatings	Rubber resistance
Decorative coatings	Touch screens
Evaporated metal coatings	MEMS

4. Some nano material test standards

To prevent any confusion in the procurement of basic quality parameters in nanotechnology applications, international test standards have been established and below are given the relevant standards.

Nano Scratch Testing:

- **ASTM D7187:** Standard Test Method for Measuring Mechanistic Aspects of Scratch & Mar Behavior of Paint Coatings by Nano scratching
- **ASTM D7027:** Standard Test Method for Evaluation of Scratch Resistance of Polymeric Coatings and Plastics Using an Instrumented Scratch Machine
- **ASTM C1624:** Standard Test Method for Adhesion Strength and Mechanical Failure Modes of Ceramic Coatings by Quantitative Single Point Scratch Testing
- **ASTM G171:** Standard Test Method for Scratch Hardness of Materials Using a

Diamond Stylus

- **ISO 20502:** Fine ceramics, advanced ceramics, advanced technical ceramics determination of adhesion of ceramic coatings by scratch testing
- **ISO 1518:** Specifies a test method for determining under defined conditions the resistance of a single coating or a multi-coat system of paint, varnish or related product to penetration by scratching with a hemispherically tipped needle.
- **ISO 19252:** method for determining the scratch properties of plastics under defined conditions.

Nanoindentation

- **ASTM E2546:** Standard Practice for Instrumented Indentation Testing
- **ISO 14577:** Instrumented indentation test for hardness and materials parameters for metallic and non-metallic coatings
- **ISO 1520:** Specifies an empirical test procedure for assessing the resistance of a coating of paint, varnish or related product to cracking and/or detachment from a metal substrate when subjected to gradual deformation by indentation under standard conditions.

5. Conclusion

Nanotechological products are manufactured by conducting expensive works. The nano scales of obtained products, their physical, chemical and material biological features are all dissimilar. This difference can only be detected via main parameters. Within own bodies of main parameters too, quality factor must be considered first. In that way the success rate of nanotechnology application can be elevated. After all not only financial profit but also trust towards nanotechnological product will also be heightened.

References:

Akdoğan, A., & Küçükyıldırım, B.O. (2006). Nanomaterials and applications. *MakinaTek*, *99*, 114-117.

Retrieved from: www.uni-ulm.de

Retrieved from: www.biotech.unl.edu

Retrieved from: www.iljinnanotech.co.kr

Retrieved from: www.mos.org/sln/SEM

Retrieved from: www.unified-eng.com/sem.html

Retrieved from: http://www.andrew.cmu.edu/user/jamess3/AFM.jpg

Retrieved from: http://photon.iyte.edu.tr

Retrieved from: www-g.eng.cam.ac.uk

Retrieved from: www.isye.gatech.edu/JCLU

Springer Handbook of Nanotechnology, Spinger-Verlag Berlin Heidelberg New York, 2004

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