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A Review of Nanomanufacturing tools and techniques for their effecective utilization in manufacturing world

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ABSTRACT

The research advancements in the field of nanotechnology have forced the companies deal with the quality and process parameters at the nano level. However, this has been a challenge for the manufacturing world to develop the metrological tools and manufacturing tools/systems which can deal at such a small level. In this paper, the path has been provided to adopt and use this technology in the manufacturing industries at regular pace rather than laboratory tests and experiments.

1. INTRODUCTION

Nanomanufacturing remains the essential bridge between the discoveries of the nanosciences and real-world nanotechnology products. Advancing nanotechnology from the laboratory into high-volume production ultimately requires careful study of manufacturing system issues including product design, reliability and quality, process design and control, shop floor operations and supply chain management.

Nanomanufacturing is the controllable manipulation of materials structures, components, devices/machines, and systems at the nanoscale (1 to 100 nanometers) in one, two, and three dimensions for large-scale reproducibility of value-added components and devices. Nanomanufacturing encompasses bottom-up directed assembly, top-down high resolution processing, molecular systems engineering, and hierarchical integration with larger scale systems. As dimensional scales of materials and molecular systems approach the nanoscale, the conventional rules governing the behavior and properties of these components, devices, and systems change significantly. As such, the behavior of the final product is enabled by the collective performance of the nanoscale building blocks.

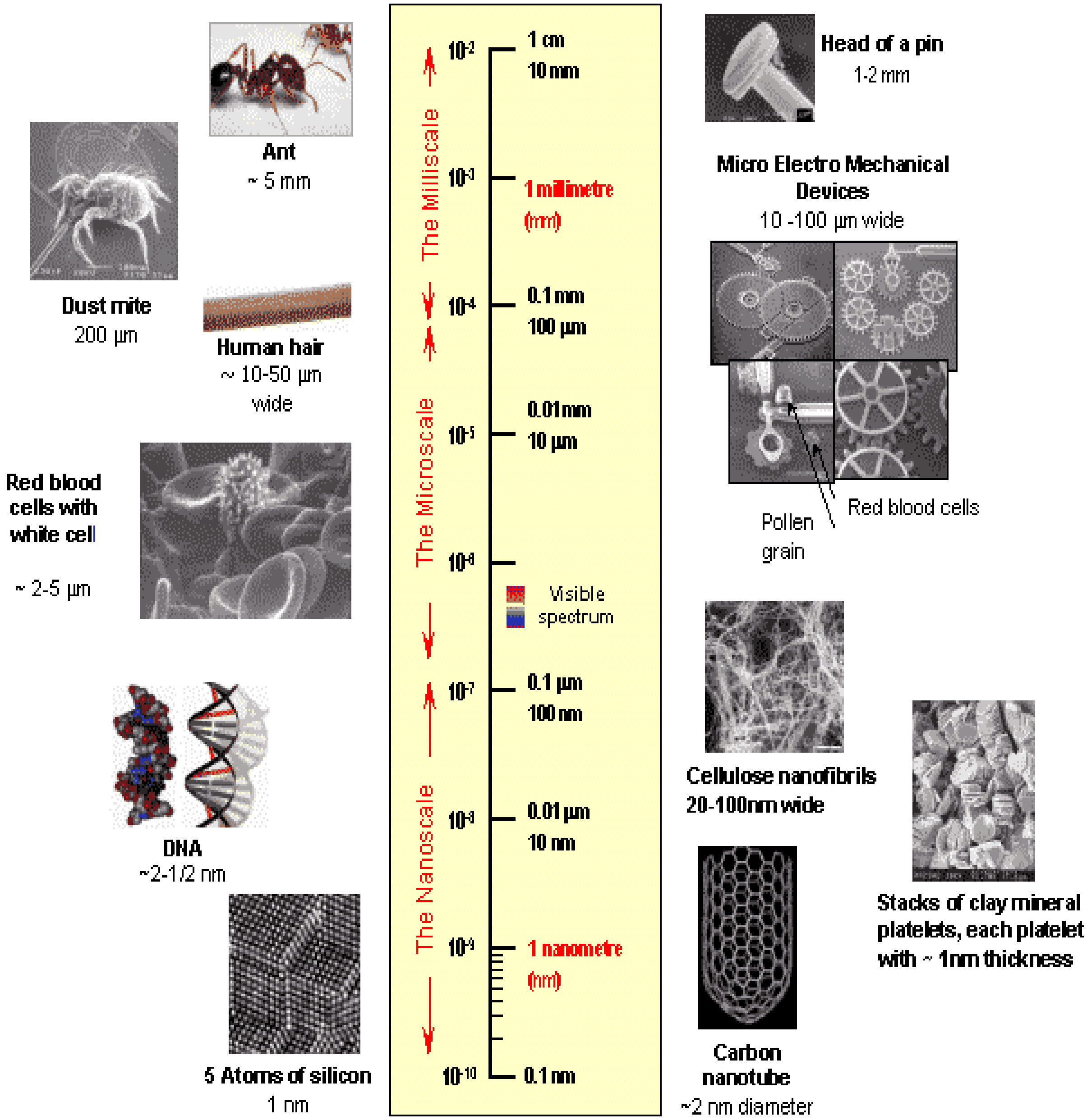

Figure 1 The presentation of nanosacle

2. LITERATURE REVIEW

During the last few years nanotechnology has changed from a technology only applied in semiconductor industry and in research laboratories to a technology that becomes also interesting to many applications in traditional branches of mechanical engineering. The dramatic improvement of ultraprecise manufacturing machines and the invention of new production techniques like Focused Ion Beam Technology has made the production of features and functional elements with micro- and nanometer size possible and economically reasonable.

In metrology, the further development of the above mentioned microscope techniques and especially special variants and related techniques has helped to establish nano metrology in research institutes and meanwhile industrial application has been taken into considerationtoo. Although both manufacturing technology and measurement instrumentation fulfil in principal several of present demands in micro- and nanotechnology, international measurement standards in nanometrology are still missing. These standards, including the calibration of instruments, the toleration of form and functional elements in the nanometer scale, new parameters and measurands for nano metrology and guidelines for reproduceable and comparable measurement results are vital for the acceptance of an industrial nano metrology in industry. AFM (atomic force microscope) cantilever has been used to join nano- particles. Small force metrology capability has been used to check the strength of joints.

The review paper authored by Tian et al. (2007) and two recently published books edited by Kienzle (2007) and Tabenkin (1993), which contain papers from nanomanufacturing researchers around the world, may serve as good initial references for nanomanufacturing techniques, even though these reviews are not exhaustive. In general, nanomanufacturing techniques are classified as either top-down or bottom-up. In the top-down approaches, materials are removed with low volumes and sizes down to the scale of dozens of nanometers. In the bottom-up approaches, materials are assembled under the guidance of nano-scale templates, either physically or chemically. Some of those techniques are inherited and extended from the traditional semiconductor manufacturing techniques, such as nanoimprint lithography and vapor deposition, since semiconductor is one of the major driving forces for nanomanufacturing.

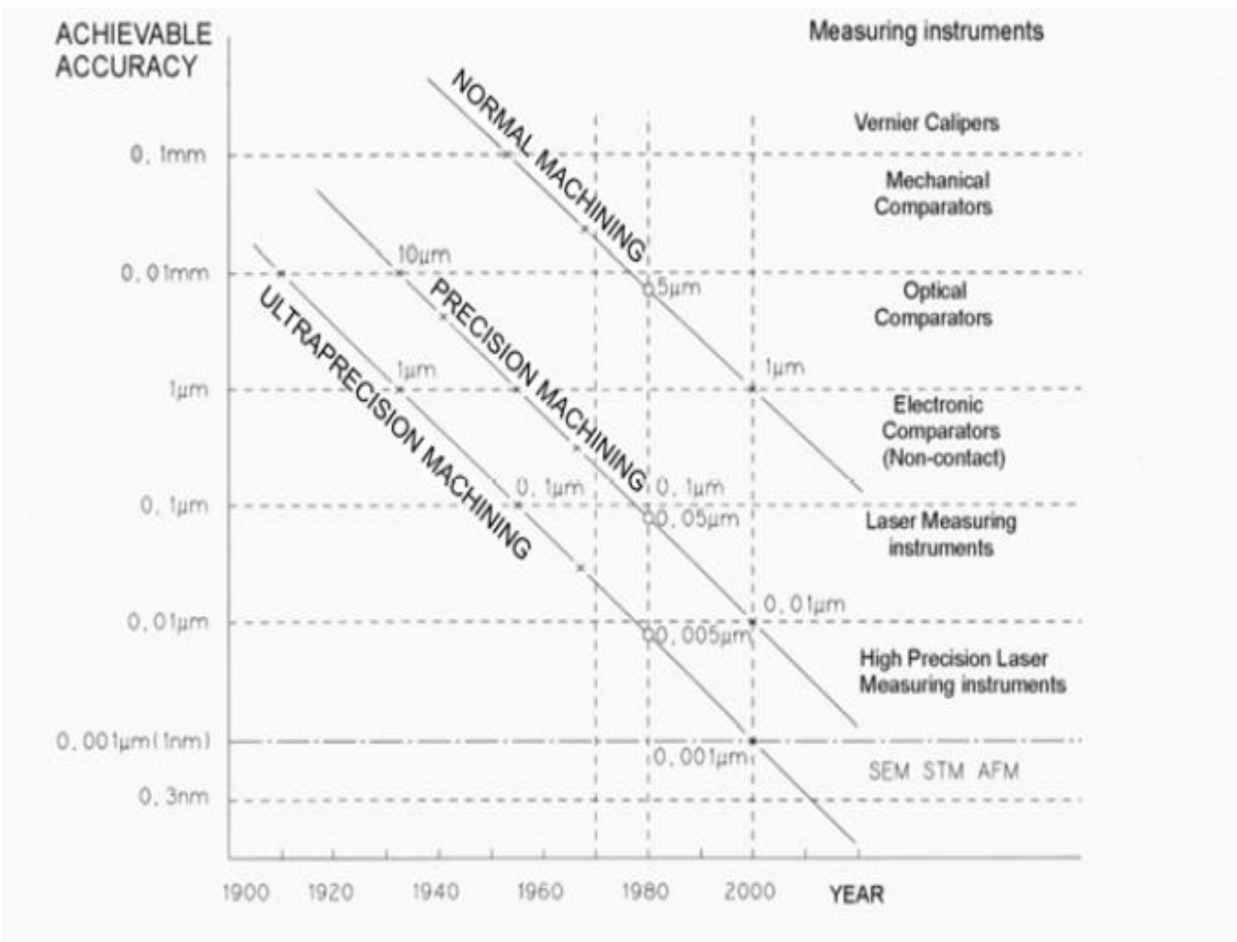

Figure 2 Accuracy achievement per year

3. MANUFACTURING AND FABRICATION OF NANOSCALE MATERIALS:

Materials aspects in nanomanufacturing encompass both the materials synthesis to achieve a specific product and performance, along with the properties of the materials that enable the nanosystems synthesis. Research priorities in materials synthesis include materials by design, deterministic fabrication, and low temperature materials and processes. Example of enabling aspects of nanoscale materials include directed self-assembly for patterning, and functional diversification wherein materials are added to an integrated nanosystem providing new functionality to the system. To maximize potential commercial impact, low cost, rapid assembly and compatibility with multiple process platforms including roll-roll processing is required.

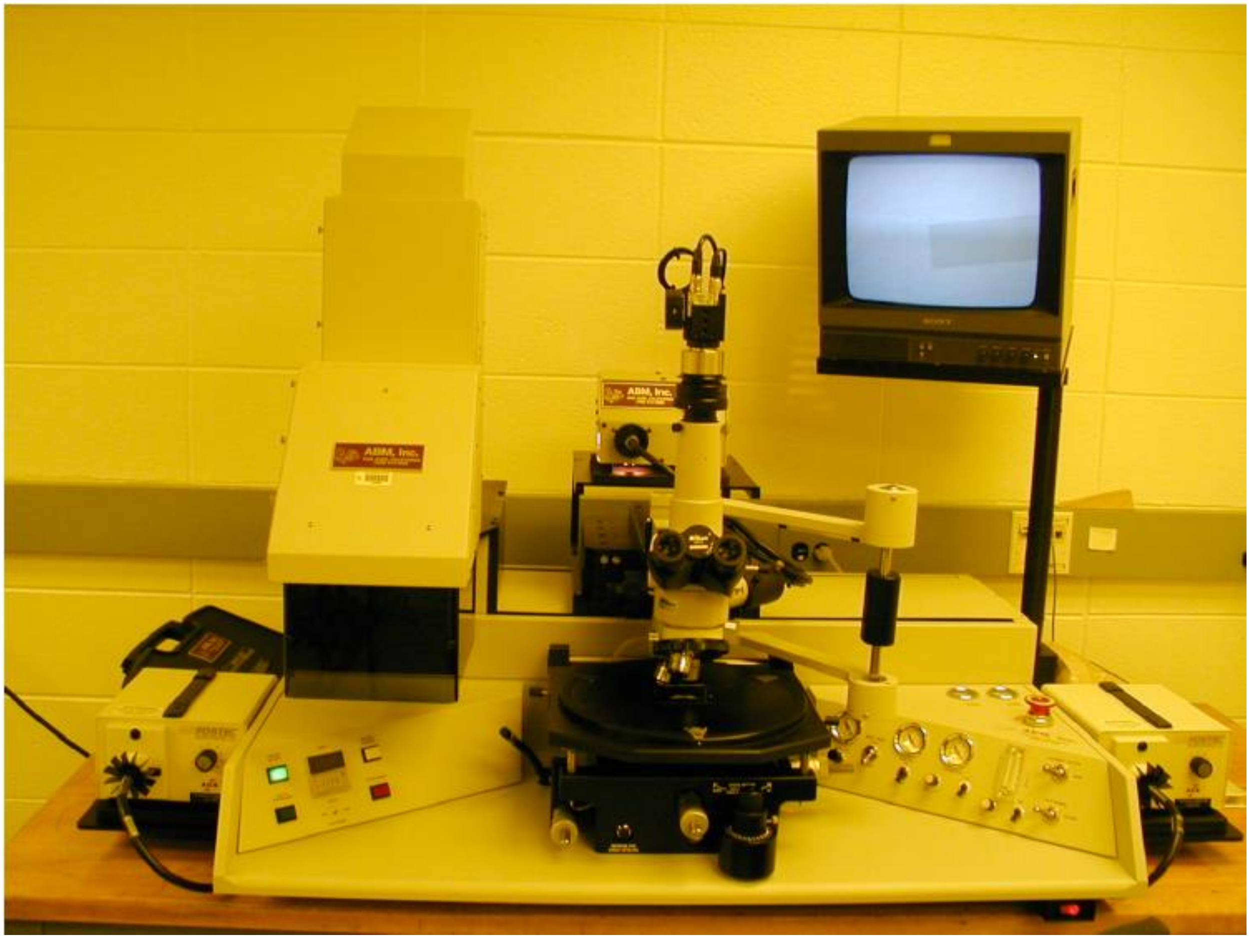

Figure 3 An e-beam lithography system.

Nanoengineered materials now entail a range of macromolecular scale components including low dimensional nanostructures, macromolecules, complex metal oxides, heterostructures and interfaces, and electronic spin devices. While nanomaterials synthesis has produced compelling examples of nanoengineering, broad issues remain in the ability to reliably synthesize specified properties. Since many materials and nanocomponent properties depend on the specific structures, the challenge remains in developing a predictive materials-by-design capability.

While the key research focus has been on the synthesis and properties of resulting nanostructured materials, less research has been devoted to understanding the relationship among process conditions, control, resulting materials structures, and aggregate materials properties. By developing a better understanding of these relationships, deterministic fabrication and synthesis may offer reduced variability, higher throughput, lower cost and improved performance for a given nanosystem design. Invariably, the challenges associated with materials properties and synthesis are directly linked to process design and control. Further challenges relate to the fabrication process when processes such as directed assembly or nano-templating are utilized to produce the material structure. Additional development of physics and chemistry-based models would predict nanosystem or component properties and performance. Directed assembly and deterministic positioning/patterning further provide scalable approaches to design of nanomaterials structures, as well as integration within the specific nanosystem design.

4. CHALLENGES IN THE FIELD OF NANOMANUFACTURING

The significant challenge for systems nanomanufacturing are the need to control assembly of three dimensional heterogeneous systems, to process nanoscale structures in high-rate/high volume applications without compromising their inherent properties, and to ensure the long-term reliability of nanostructures through testing and metrics. These challenges reflect the need for research in the characterization of nanomaterials and nanoparticles as the building-blocks of nanostructures and in the fabrication and synthesis of both top-down and bottom-up processes. Further, they require advanced instrumentation to characterize and measure nanostructures in order to provide predictive simulation of nanostructure behavior, and to contribute to the design and integration of nanodevices and systems. Finally, knowledge sharing and outreach is a challenge to be overcome to enable technology transfer and to contribute to public awareness of nanotechnologies. They may be summarized as:

- To bring nanomanufacturing to common use in the industries rather than laboratory tests and research.
- To reduce the cost of the tools/systems used in nanomanufacturing.
- To make available the vendors for providing nanomanufacturing tools and machines in developing countries like India.
- To generate fabrication techniques for all types of nanomaterials.

CONCLUDING REMARKS

The paper is concluded by saying that ‘‘No doubt, baby's birth is associated with different kinds of normal pains, even caesarean may be necessary in some cases; if the baby is hale and hearty, then, all such kinds of pains are forgotten. Only need of the hour is to design and develop different kinds of painkillers in the form of hardware and software technologies which make the technology adoption and implementation easier.’’

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