

## NANOTECHNOLOGY:

### What is it (not) about ?

#### - 5 Statements of the Head of the German Competence Center "HanseNanoTec" (Roland Wiesendanger) -

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1. *Nanotechnology is **NEW**.*

Nanotechnology has emerged from **recent** developments and discoveries in the areas of visualization, analysis, and manipulation of nanometer-scale and atomic structures, controlled synthesis of new functional materials, and nano-scale devices based on phenomena occurring in systems of reduced dimensions which are typically governed by quantum-mechanical behaviour. In particular, the developments of scanning tunnelling microscopy and related scanning probe methods have provided novel insight into nano- and atomic-scale properties of materials at energy scales which are far below the molecular binding energy scales (and are therefore non-destructive). Moreover, the discoveries of new nano-scale materials like fullerenes, carbon nanotubes and other nanotube materials, as well as the **controlled** synthesis of nanoparticles of well defined size and shape have triggered enormous activities. Finally, new nano-scale devices such as single-electron transistors or quantum dot lasers have become feasible thanks to the improved understanding of the physics and the materials' design on the nanometer and sub-nanometer length scale.

2. *Nanotechnology is **CLEAN**.*

All three ingredients of nanotechnology described above involve clean and well controlled processes which are typically conducted under ultra-high vacuum conditions or in ultra-clean liquid solutions. The mass production of nano-scale particles without control of their size and shape, as has already been introduced decades (and in some cases centuries) ago and which, in principle, results from any industrial process leading to exhausts, dusts and waste, **cannot** be considered to be part of **nanotechnology**, since any technology requires the **control** of the processes involved and the products which result from the application of that technology.

3. *Nanotechnology involves **SCIENTIFIC BREAKTHROUGHS**.*

Nanotechnology has been driven by scientific breakthroughs such as the invention of the scanning tunneling microscope and related scanning probe techniques as well as the discovery of new classes of nano-scale materials such as fullerenes or carbon nanotubes. The ability to visualize, analyze and manipulate matter down to the atomic and molecular scale forms the basis for a comprehensive understanding of physical, chemical and biological properties and processes at the nano-scale. Based on this knowledge, the design of new nano-scale devices becomes feasible which make use of the inherently different properties of nano-scale materials compared to the corresponding bulk.

4. *Nanotechnology is the key for **PROGRESS** in existing industrial branches.*

Basically all branches of modern technologies, including information and communication technologies as well as biotechnology, rely on handling large amounts of data. The amazing development of semiconductor-based electronics and magnetic materials-based ultra-high density data storage has led us to the nanometer-scale regime with respect to minimum feature sizes in silicon-based transistors or magnetic bits in hard disks. Current developments in these areas heavily profit from the application of novel fabrication and analysis tools which have become available in recent years as a result of world-wide activities in nano-scale science and technology. Future progress will strongly depend on smart concepts to combine these "mainstream" developments with novel nano-scale functional units making use of quantum-mechanical confinement, single electron effects or single spin manipulation.

5. *Nanotechnology opens up **NEW DEMANDS** and **MARKETS**.*

Looking back to history, technological developments have always led to new demands by our societies and therefore to new markets rather than the other way round. Cars, computers, handys etc. have never been developed as a response to the need expressed by a large number of people. They became available thanks to an improved understanding of physical principles and improved technological skills by scientists and engineers. Therefore, a society-based demand analysis in order to determine future technological developments is not helpful. Nanotechnology will lead to a wide range of new products which we can hardly imagine at this time. They will create new demands and therefore new markets as in all previous "technology ages". To limit our activities to only those fields which we can overlook at the present time would strongly hinder further technological breakthroughs which have often resulted from visions of a single person or a few people rather than from "mainstream" thinking.