The distinctness of nanoscience, engineering and technology

We have seen how the scientific discoveries and technological inventions of the past three centuries have revolutionized the manufacturing sector and society. The common traits of the new technologies that transformed human and social life between the first Industrial Revolution and the Digital Revolution were that they were designed for large-scale production which was capital energy-intensive, in need of large manufacturing infrastructures and competing in the global markets. Big became beautiful and the manufacturing processes and methods were aligned along the macro-principle. The transistor and semiconductor industry inaugurated a change in that trend, and small became beautiful and manufacturing began to focus on micro and then on nano.

Nanoscience and technology requires nanomaterials. Manufacturing of nanomaterials is not just a step further down in size; it is about using the knowledge of the atomic realm to produce novel artifacts in a cheaper and cleaner way, with reduced capital and energy inputs and with more precision. The unparalleled development of nanotechnology and the dissimilar preconditions for nano show that nano-scale science and technology is different from the precedent and other newly emerging sciences and technologies. We highlight a few of the most salient peculiarities that explain the distinctness of nanoscience and manufacturing of nanomaterials. First, at the nanometer scale, science and technology converge and therefore go beyond the traditional boundaries of disciplines. Nanoscience is of trans-disciplinarity nature since it involves chemistry, physics, mathematics, cognitive science and life-sciences, in particular genomics and proteomics. Nanotechnology fuses with other recent technologies like information and communication technologies and biotechnology. Second, control and manipulation of the very elementary building blocks of all objects of the living and non-living world – atoms and molecules – enable modification of the same, which can influence every area of life. In other words, the core novelty in science and technology on the scale of the nanometer is that scientists and technologists do not invent the world *ex novo* as in the past, but *de novo*, since the new artifacts are made of components which have no natural analogues. Third the term nano refers to measurement, the nanometer as it indicates the size of the matter being observed and manipulated and the term does not refer to any object *per se*. This explains the unlimited spectrum of nano since all physical matter, irrespective of its nature, can be measured, and the only condition is that measurement facilities for that size regime exist. Fourth, manufacturing of nanomaterials does not need the enormous initial capital outlays for industrial infrastructure that other technology require and therefore gigantic technological parks have become obsolete, at least in cases where shape control of the nanoobject is not a stringent condition. Factual examples substantiating the assumption that production can be cost-effective and tailored to local needs either large or small – are available. These examples include the production of nanomaterials through biology. A further novel aspect with regard to nano-technology that gives a practical expression to the pace of technological change is the reduction in time from the scientific discovery to the application of the new knowledge.