Current Progress and Future Opportunities in Nanotechnology

M.C. Roco
National Science Foundation and National Nanotechnology Initiative, U.S.

Nanotechnology R&D has changed its focus, industrial relevance and governance since 2000 when was proposed in various national programs as a key science and technology development for 21st century [1]. This presentation outlines the progress in foundational knowledge development, its current status supporting about $80 billion production incorporating nanoscale components only in the United States, and likely evolution towards a general purpose technology by 2020. Nanotechnology has already powerful implications in knowledge foundation, advanced materials, nanoelectronics, molecular medicine, energy conversion and storage.

In the first decade (about 2001-2010) the main goals have been understanding individual basic phenomena, synthesize components as building blocks for potential future applications, tool advancement, and improving existing products by using relatively simple nanoscale components. In the second foundational phase (about 2011-2020), there is a R&D transition towards direct measurements on three-dimensional domains with good time resolution, science – based design of fundamentally new products and mass use of nanotechnology. The focus of R&D and applications is expected to shift to complex nanosystems, new disciplines and areas of relevance leading to novel products and services. An increased focus is on sustainable resources including water, food, energy, materials and clean environment. The convergence of nanotechnology, modern biology, the digital revolution and other areas are expected to bring about tremendous improvements in transformative tools and societal outcomes.

General trends in nanotechnology funding, publications and technology transfer will be outlined. For illustration, the number of patent applications has increased at an annual rate of about 35% between 2001 and 2008 [2], about 10% faster than the annual rate of increase of paper publications. At the same time, in 2008, the relative proportion of nanotechnology contributions is about 11% in National Science Foundation new awards, about 4.5% in journal articles and 1.5% in USPTO patent awards (see Figure 2, after [3, 4])

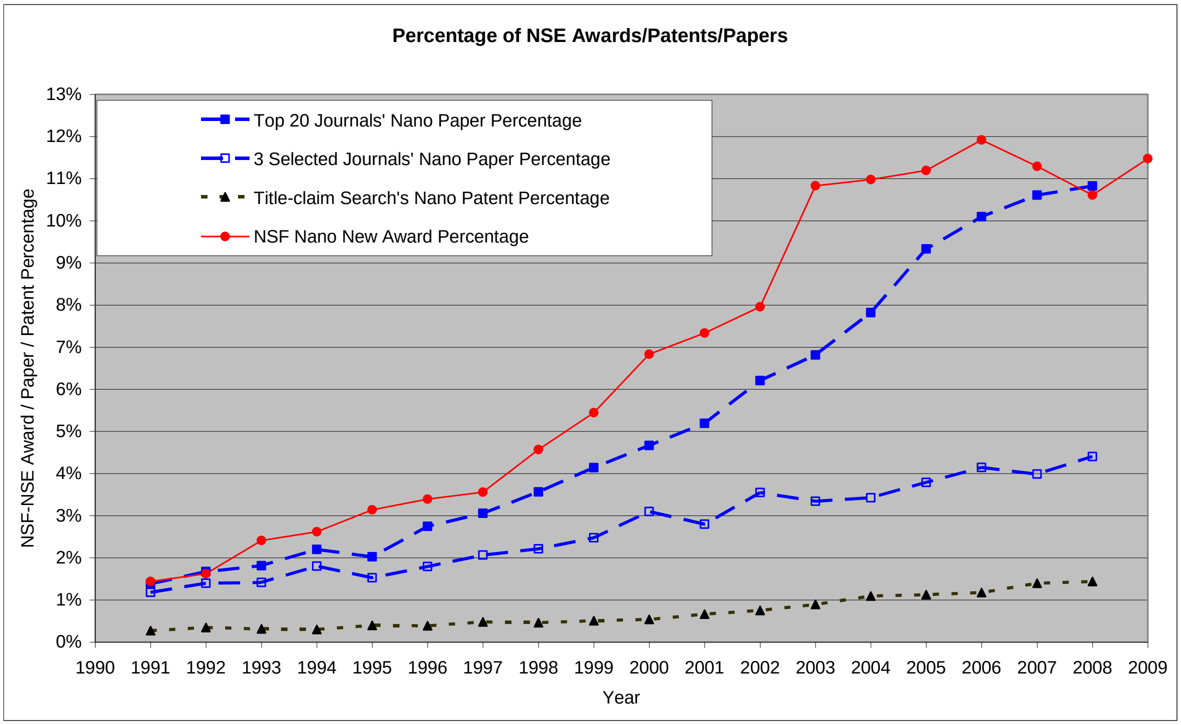

Figure 1. Nanotechnology contents in NSF awards, ISO papers and USPTO patents (1991-2009).

We will discuss possibilities for a transformative, global, long-term view and responsible governance approach of nanotechnology. Regulation may be an enabling or constraint of technological innovation, two sides of the same coin. Five ideas are advanced to address the challenges of the new generations of nanomaterials: (1) making available open sources systems to promote global self-regulation, (2) creating and leveraging S&T nanotechnology platforms, (3) addressing the sustainablility of resources as well as environment, health, and safety

(EHS) issues and unexpected consequences, (4) support global communication and international cooperation, and (5) commiting to a long-term, global, priority-driven governance supported by reliable system to monitor developments and detect problems. o the need to transform education in the face of such radical technological and risk governance challenges.

References

1. “Nanotechnology Research Directions” (MC Roco, RS Williams and P Alivisatos), Springer, Dordrecht, 1999; and US National Science and Technology Council, Washington, D.C., 2000.
2. “Trends in Worldwide Nanotechnology Patent Applications: 1991 to 2008” (Y Dang, HC Chen and MC Roco), J. Nanoparticle Res., Vol. 11 (3), 2010.
3. “National Nanotechnology Initiative: Past, Present, Future” (MC Roco), Handbook on Nanoscience, Engineering and Technology, 2nd Ed., Taylor and Francis, 2007, 3.1-26.
4. “Mapping Nanotechnology Innovations and Knowledge” (HC Chen and MC Roco), Springer, 2009.