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**Introduction to Nanoscience Education and Research at Arizona State University**

In the ten years since 2002, Arizona State University (ASU) has undertaken an aggressive transformation, emphasizing the importance that universities should not only be resource centers for educating and training students, but also be actively engaged in developing solutions to many of society’s technological and sociological problems. One of the design challenges of “The New American University” is dedicated to the concept that “use-inspired” research addresses those needs directly in the classroom and in research and that the process of working towards solutions is a better way for students, faculty and the community to learn. The process of “doing” is a more efficient alternative to purely “curiousity-driven” research in meeting society’s needs. In accepting this philosophy, ASU has more than tripled its research enterprise in terms of funding and productivity, and has also doubled the number of students that it serves. There is an underlying belief that it is possible to increase the quality of a university at the same time as increasing its size and scope. The growth of education and research activities in nanoscience and nanotechnology at ASU exemplifies these developments.

This presentation provides an overview of ASU’s transformation and specifically describes many of the research and education activities that are taking place in the general field of nanotechnology. It begins with descriptions of areas of excellence that ASU has long had, such as in materials characterization through its leadership in high resolution electron microscopy and scanning tunneling electron microscopy. It then describes examples of its recent innovations in applying nanoscience and nanotechnology for developing inexpensive ways to sequence DNA molecules, for using DNA for non-biological purposes that pattern and construct ultra-small electronic devices, for developing new chemical and photon sensors, and for mass production nanodevices to be included in large area displays.

This presentation also describes education and science policy programs that center around nanoscience and nanotechnology. It particularly focuses on the objectives of ASU’s “Center for Nanotechnology in Society”, which studies and projects the beneficial and deleterious influences of nanoscience, and especially nanomaterials, in society. In trying to predict these effects, it’s goal is to accelerate the development of policies that will protect the safety of our living environment, while ensuring the benefits that will come with these new developments.

**Alternative Chemical Design for Functional Nanoceramics**

Science and technology has always dwelt on the nature of materials at the very fine scale. After all, our modern conceptions of quantum mechanics is very much entwined with our understanding of materials at the nanometer scale. However, as fields of intensive study and technological application, nanoscience and nanotechnology has taken place only within the last sixty years with the simultaneous evolution of semiconductor electronics reaching from micron to mesoscopic dimensions and, in the opposite direction, of molecular science expanding into increasingly complex supramolecular designs. With respect to nanomaterials, one might argue that a new age of enhanced awareness began with the discovery of fullerenes in the late 1980’s.

This new age kindled all kinds fantastic of new ideas that large individual molecules could be individually manipulated, to form the essence of a new electronic device, or to self assemble into larger distinctive molecules with greater functional complexity. It gave rise to ideas of combining semiconductor technology with macromolecules and extremely small particles as basic building blocks for new devices that could detect single molecule reaction events or process logic decisions. There are now many amazing stories that matter can indeed be manipulated at the molecular level. However, a continuing challenge is how to massively incorporate nanomaterials into large monolithic and bulky objects to take advantage of both the large-scale and small-scale materials properties at the same time. This presentation gives two examples where old concepts of materials fabrication were refreshed with the chemical redesign of the precursor and reaction chemistry to producing those materials.

In one example, magnetic nanoferrites were deposited as thin and thick films by modifying a low-temperature, aqueous deposition technique that has been pioneered in Japan. We principally focused (Ni,Zn,Co,Fe)3O4 spinels that exhibit soft-ferrite magnetic behavior in a dense nanocrystalline state. Towards making components larger, we have developed techniques for both thicker films and lamination to preserve the magnetic properties of the thin film nanocrystalline films.

In the second example, well-ordered crystalline nanocomposites of mullite (Al6Si2O13) and lanthanum monazite (LaPO4) were produced from glassy precursors that were chemically designed with a complexity to separate the glass transition and crystalline temperatures by 200˚C. This allowed large ceramic objects to be densified by a viscous sintering step at low temperatures and then crystallized into a nanocomposite at higher temperatures. Manipulation of the process provides examples of different nanocomposite structures including those with continuous mullite matrices, continuous monazite matrices, and thermally stable, openly porous structures that only 15% dense.