Chapter 42
Interdisciplinary Course Development in Nanostructured Materials Science and Engineering

Kenneth L. Roberts
King Faisal University, Saudi Arabia

ABSTRACT

Modern industrial processes are presently adapting to the use of multiscale production techniques where consumer products can be made at the mesoscale and also approaching atomic, or the nanoscale level. Coupled with the fact that classical Science, Technology, Engineering and Mathematics (STEM) education typically does not address nanoscale science and engineering topics in most technical courses, this condition could potentially leave countless STEM students around the world relatively unprepared for the 21st century marketplace. This chapter focused on the development of the nanostructured materials science and engineering discipline from the most recent research and development topics to the integration of this information internationally into the technical classroom. The chapter presented future work on the adaption of the previous research and educational work on this topic at the College of Engineering at King Faisal University in Saudi Arabia and suggestions were offered for successful new nanoscale science and engineering course development.

INTRODUCTION

Over the past twenty years, nanomaterials science and engineering has become almost pervasive in the technical disciplines. In the early 1990's, the reporting of material properties on the scale of submicron scale using scanning and/or transmission electron microscopy seemed to be at the cutting edge. After the discovery of the Buckyball (C_{60} or Buckminsterfullerene), new terms such as nanotubes, nanoparticles, nanowires and a varied assortment of atomic scale crystalline morphologies quickly gained notoriety. Unfortunately, not every academic program, especially B.S. and M.S. level granting programs, had

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access to nanoscale characterization equipment such as transmission electron and scanning tunneling microscopes, required to fully peer into the nanoscale. Thus a nanoscale divide in Science, Technology, Engineering and Mathematics (STEM) education had also begun. Unfortunately many STEM students from universities with developing research infrastructures gained college and graduate level degrees without significant training in nanoscale science and engineering.

BACKGROUND

Development and Implementation of Nanoscale Materials Research and Education Initiatives: Global Initiatives

Since the beginning of the 21st century, several countries including the United States have begun large government-funded initiatives to prepare pre-college, college-level and graduate-level students for careers in nanoscience, nanotechnology and nanoengineering. In the U.S., the National Nanotechnology Initiative (NNI) first approved for funding in 2001 sought among other goals to increase the interdisciplinary nature of research and development and to explore the broad societal impacts of nanotechnology (Roco, Mirkin, & Hersham, 2011). International literature have reported from the late 1990's on the development and implementation of nanoscale materials research, and educational initiatives are still ongoing. In Table 1, a comparison of national government support of nanotechnology research and development funding is provided.

In many countries such as Germany, South Korea and the Russian Federation, the primary goal of nanoscale research centers and institutes was initially to provide professional conduits for corporate researchers and academics to develop nanoscience research into finished industrial products (Rieke & Bachman, 2004; So, Kim, Chung, & Jhon, 2012; Klochikhin, 2011). Universities were tasked to focus on nanoscale student training mainly for industrial applications research for commercial products and technical publications. Over time, the participating universities developed graduate and undergraduate nanoscale education programs. For example during the 2004-2005 academic year in the E.U., there were 19 Ph.D., 78 M.S., and 28 undergraduate nanotechnology programs (Malsch, 2008).

On the state of global nanoscale educational initiatives at the university level, there have been recent reviews published (Feather & Aznar, 2011; Mohammed, Lau, Zaharim, & Omar, 2012). The work by

Table 1. Federal/national government nanotechnology research & development funding, 2008

Country/Region	Government Nanotechnology R&D Funding (Millions $ U.S.)	Specific Nanotechnology R&D ($ U.S./Capita)
European Union	~1770	~4.6
U.S.	~1550	~5.1
Japan	~950	~7.3
China	~430	~0.4
Korea	~310	~6.0
Taiwan	~110	~4.5

(Roco et al., 2011).