NIRT for Biomedical Nanotube Technology

NSF NIRT Grant EEC-0210580

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We are conducting the first-ever broad-based and systematic research effort on the development of nanotube technology for biomedical applications. Our research objectives include: **1.** To develop nanotube-based technology for biosensor and medical diagnostic applications. **2.** To show that such nanotubes can be capped via self-assembly chemistry with nanoparticle caps. **3.** To demonstrate that these nanoparticle caps can be attached via chemical bonds that dissociate when a specific intercellular chemical signal is detected. **4.** To show that such nanotubes can be tagged on their outer surfaces with antibodies that recognize specific cell types. **5.** To develop and investigate nanotubes based on biodegradable and biocompatible materials for this and other *in vivo* biomedical applications

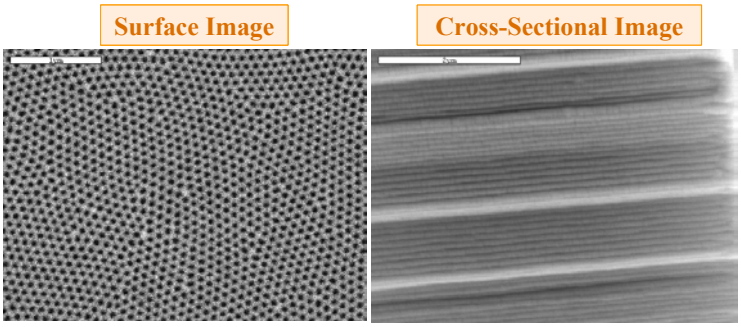
The nanotubes are prepared by the template-synthesis method (1). This general and extraordinarily versatile approach for preparing solid nanowires and hollow nanotubes was pioneered in the PI's laboratory. It has become one of the workhorse methods for preparing such nanostructures and is now practiced in laboratories throughout the world. The key advantage of template synthesis is that nanotubes composed of nearly any material or combination of materials can be prepared. This is an extremely important attribute because with template synthesis, the materials to be used to prepare the nanotubes can be selected so that they are perfectly and ideally suited for the biomedical/biotechnological application at hand. That is, with template-synthesis, one is not stuck with trying to retrofit a particular material (e.g., the carbon that makes up fullerene nanotubes) to the biomedical application at hand. Put another way, with template synthesis, one can make "designer nanotubes." This idea is illustrated in Table 1 which lists some of the materials we and others have used with template-synthesis to make such designer nanotubes."

Table 1. The concept of template-synthesized designer nanotubes - Some materials that have been used to make designer nanotubes and the key properties that make these nanotubes useful.

Material	Properties
Metals	Electronic properties, tunable optical properties, magnetic properties.
Semiconductors	Electronic properties, photochemical activity.
Polymers	Tunable electronic, optical, solubility, and mechanical properties.
Biodegradable polymers	Biodegradability.
Biocompatible materials	Biocompatibility.
Silica	Easy chemical and biochemical functionalization, transport properties.
Carbons	Electrochemical properties, transport properties, electrokinetic phenomena.

Template synthesis begins with a nanopore membrane such as the nanopore alumina shown in Figure 1. These membranes contain cylindrical pores with monodisperse diameters. The pores in this membrane are used as templates to prepare the nanotubes. As illustrated in Figure 2, this is accomplished by synthesizing or depositing the tube-forming material along the pore walls of the template. A scanning electron micrograph of an array of carbon nanotubes prepared by chemical vapor deposition template synthesis is shown in Figure 3.

Figure 1. Template Synthesis Begins with a Nanopore Membrane or Other Solid



This research effort is being conducted in collaboration with the University of Florida Engineering Research Center for Particle Science (www.erc.ufl.edu) and the University of Florida Center for Research at the Bio/Nano Interface (http://www.uf-bio-nano-center.org/). We also have industrial partners including the Broadley James Compnay (Irvine CA) and EIC Labs (Norwood MA).

Figure 2. Nanotubes that Line the Pore Walls can be Synthesized or Deposited within the Pores

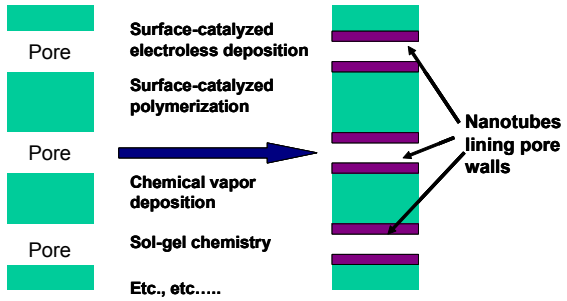
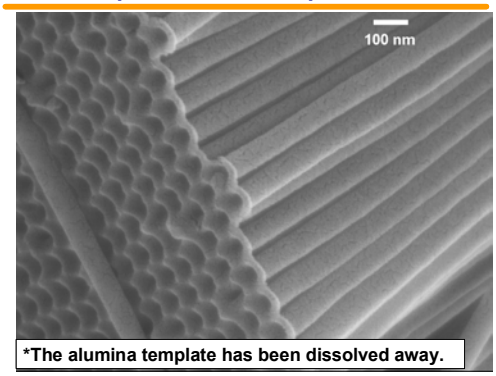


Figure 3. Carbon Nanotubes Prepared by Chemical Vapor Deposition within the Pores of a Nanopore Alumina Template



References.

1. For reviews of template synthesis of nanotubes see. Martin, C.R.; Kohli, P. "The Emerging Field of Nanotube Biotechnology," *Nature Reviews Drug Discovery*, **2003**, 2, 29-37, and Wirtz, M.; Miller, S.A.; Martin, C.R. "Transport Properties of Template-Synthesized Gold and Carbon Nanotube Membranes," *Internat. J. Nano.*, **2002**, 1, 255-268.