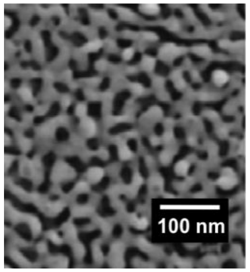
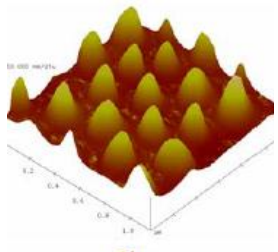
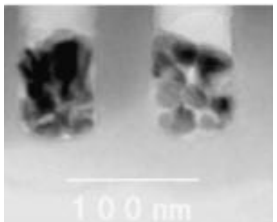
Zangari Group







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Electrochemical phenomena provide unique methods for materials synthesis and surface modification. Within this framework, the group is developing the fundamental science and synthetic abilities necessary to tailor to specification materials and components for a variety of devices, focusing on micro/nano-electronics and magnetics, with a recent emphasis on energy conversion applications. Our work encompasses the electrochemical deposition of metals, alloys and semiconductor materials, the electrochemical formation of a variety of self-assembled nanostructures, as well as the development and integration of suitable components for information storage, sensors and energy conversion devices.

"Further the understanding and control of atomistic phenomena occurring at electrolyte-solid interfaces for use in electronic and energy conversion devices."

University of Virginia
ENGINEERING

Electrochemical Materials Synthesis

We have demonstrated a number of electrochemical processes for the synthesis of novel magnetic alloys, focusing on electrolyte development and on the optimization of magnetic properties (anisotropy, coercivity) through control of alloy composition, crystallographic structure and orientation, micro- and nanostructure. Material systems include alloys with large magnetic anisotropy for novel information storage paradigms such as patterned media. In particular, we have achieved close compositional control and low impurity content in Fe-Pt alloys, and ordering of the equiatomic alloy after mild thermal annealing. In the area of spin electronics, we have shown the electrochemical synthesis of sharp, epitaxial interfaces between magnetic metals or alloys and Ga(Al)As, suggesting potential for use of these interfaces as spin filters in prospective spin transistors. More recently, we have been investigating the fundamentals of alloy electrodeposition, focusing on the role of thermodynamics and kinetics in determining alloy composition, crystalline phase(s) and microstructure. We found that at low deposition rates (near the thermodynamic limit) the composition of alloys with a large exothermic heat of mixing can be predicted simply from the thermodynamic properties of the corresponding bulk alloy.

Electrochemical Fabrication of Nanostructures

Nanoporous metals, semiconductors and oxides are synthesized electrochemically and investigated as (i) templates for the growth of nanomaterials (nanoporous alumina, titania nanotubes, porous silicon), (ii) molecular filtration membranes (straight pores in porous silicon, constrictions in porous alumina), or (iii) templates for enhanced cell growth (composite oxide nanostructures, nanoporous gold). Additionally, functionalization of these surfaces via organic (self-assembled monolayers SAMs) or inorganic (metal oxides or compound semiconductors) materials is being pursued to develop electrochemical sensors or photoelectrochemical solar cells.

Green Processing and Electrochemical Energy Conversion

Various efforts on these themes have been undertaken over the years. We have investigated novel materials and electrochemical processes for the possible substitution of Cd in sacrificial corrosion coatings, by focusing on various Mn alloys; we found that small Cu additions to Mn enhance the stability of the ductile Mn phase and vary the open circuit potential, allowing control over the corrosion rate. We have also examined materials and operational aspects of alkaline hydrogen electrolyzers. For example, we have studied electroless Ni-based alloys as alternative hydrogen evolution catalysts, as well as the influence of operational conditions on device efficiency. The formation of Pt nanoparticles on graphite and on Si was also investigated, in view of their potential use as catalysts for hydrogen evolution in electrochemical or photoelectrochemical systems. More recently, we started a sustained effort on the development of photoelectrochemical solar cells for hydrogen production using low cost synthesis techniques and environmentally friendly, abundant materials. We are currently exploring the ability of metal oxides (Cu_2O, Fe_2O_3) to extend the absorption of radiation by TiO_2 nanotubes in the visible range, and the effect of such modification on the overall system efficiency.

RECENT RESEARCH DEVELOPMENTS

- Determined crystallinity improves the photoelectrochemical performance of titania nanotube arrays.
- Electrochemical synthesis of metastable binary alloys enables control over the degree of metastability.
- (with Knospe, Reed) Novel dielectric materials to enhance efficiency of electrowetting devices.

RECENT GRANTS

- Encell Technology, Inc.-Hydrogen recombination and control in iron cathode alkaline battery systems
- NSF-Fundamental studies on tailored surfaces with application to high performance capillary force actuators
- NSF-Novel catalysts for electrochemical carbon dioxide conversion: from bimetallic surfaces to gas diffusion electrodes

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