Alfred University

INAMORI SCHOOL OF ENGINEERING

Graduate Research Opportunities starting January 2011

Coatings for Corrosion Control

To date, hexavalent chromium is the most effective inhibitor of corrosion for aluminum, steel and magnesium alloys. Yet, since 1982 the use of chromates and other chromium-containing compounds has been limited due to their carcinogenic effects. It is believed that the environmentally-friendly formulation of inorganic magnesium-rich coatings can provide exceptional protection for aluminum- and magnesium-based alloys and will be the next alternative to chromates. Our work will focus on the analysis of metal rich coatings using electrochemical and surface analysis techniques to determine their effectiveness as corrosion protective coatings on reactive metal alloys. MS student preferred.

Trivalent-Cation Tungstates

Most ionic conductors conduct charge via the movement isolated monovalent or divalent species such as Na+ or O2-. Some researchers report that conduction in trivalent-cation tungastates, such as Sc2(WO4)3, involves trivalent cations whereas others propose the rotary movement of WO42- groups. This project will investigate this interesting class of materials using electrical conductivity measurements, diffraction techniques, and computer modeling in collaboration with researchers at the National University of Singapore and Ural State University in Russia. Graduate students working on the project will have several opportunities to travel abroad to conduct research and to attend international conferences. PhD student preferred.

Layered Photocatalysts

Many perovskite-derived structures may host the photocatalytically active Ti and Nb cations and the local environment around these cations can be varied by substitutions onto the perovskite A sites. The project focuses on solid solutions in the Aurivillius system that will strain the Ti-O and Nb-O bonds to probe the effects of bonding on photocatalytic activity. There exists the opportunity to complement the experimental work with quantum mechanical computer models to understand the factors governing catalytic activity. PhD student preferred.

Research OPPORTUNITIES

Thermoelectric Oxides

This project involves the design, synthesis, and characterization of new oxide materials. Graduate students will gain experience in synthesis, diffraction, and electrical measurement techniques. PhD student preferred, MS student with strong interest in this topic will be considered.

Thermoelectric Devices

Thermoelectric devices are being considered as means of converting waste heat to electricity. This project will involve the design, fabrication, and evaluation of prototype devices using enameling technology. Graduate students will gain experience in materials (glass and ceramic) processing, device fabrication, and characterization. MS student preferred.

Spectrally Selective Coatings

Spectrally selective coatings that preferably absorb solar radiation but transmit thermal-IR radiation are used in solar-thermal conversion systems. Textured thin-film ceramic coatings are being developed in collaboration with an industrial partner. This project will investigate how thin-film deposition parameters and post-deposition processing affects the optical properties of these films. Students will gain experience with x-ray diffraction, optical spectroscopy, and other characterization techniques. MS student preferred.

Hollow Gas Microspheres

Hollow gas microspheres are currently under study at Alfred University for use as hydrogen storage media. These tiny spheres (<100μm) can contain gases with pressures of at least 10,000 psi. A number of other applications for gas-filled hollow glass microspheres are currently under consideration. Graduate students working on this project will have the opportunity to develop new technology based on these materials, for applications including microbatteries and a number of optical applications. MS student with the potential for continuation to the PhD is preferred.

Nanocrystal Formation in Glasses

Current research at Alfred has resulted in the formation of a large variety of new glasses which contain nanocrystals of magnetic, metallic, or semi-conducting materials. Several of the materials which have been produced as nanocrystals in glass have not been reported in the literature. These materials offer potential for a wide variety of new applications. MS or PhD students will be considered.

Numerical Modeling

Investigations of industrial materials and processes via Finite Element Analysis. Fundamental modeling of the continuum mechanics of materials. Development of models and techniques to predict the response of materials. MS student will be preferred.

Bioactive Glasses

Bioactive glasses undergo a sequence of reactions in a physiological environment that accelerates the formation of natural, living bone. More recently, bioactive glasses have been found to possess additional functionalities including anti-microbial and anti-inflammatory properties. Current work focuses on developing compositionally novel bioactive glasses that release dissolution products to stimulate a specific physiological response. MS or PhD student considered.

Magnetic Levitation Using Digital Signal Processors

This project addresses real-time magnetic levitation (maglev) control using digital signal processing (DSP). A maglev system will be developed to keep a ferromagnetic object suspended, without contact, beneath an electromagnet, and to move the suspended ferromagnetic object to simulate a maglev train. MS electrical engineering student with good background in control and digital signal processing preferred.

Tailoring Grain Boundary Phases in Polycrystalline Ceramics

Work conducted on porcelains indicated that the glass phase in porcelains lies on the glass formation boundary in the system. Other work indicates that the glass formation boundary is remarkably similar for a wide range of systems. It is proposed that this idea may explain low-temperature (initial-stage) sintering in advanced ceramics and that the grain boundary phase can be specifically tailored by exploiting the glass formation boundary. Other opportunities may be to better control both the sintering temperatures and the microstructure evolution in advanced ceramics. Both MS and PhD students will be considered.

Determining the Firing Temperature of Ancient Ceramics

The glass phase of porcelain was determined to lie on the glass formation boundary within the alkali-alumino-silicate system. The amount of silica, based on the molar ratio (such as on a Seger formula basis), scaled linearly with temperature. This relationship can be used to uniquely determine the firing temperature of dense traditional ceramics such as ancient porcelain, thus providing a unique opportunity for archeological evaluation. Both MS and PhD students will be considered.

Development of High-Performance Concretes Using Conventional Portland Cement

Preliminary work conducted using manufactured shaped aggregate indicates that significant improvements in concrete strength can be obtained by controlling the interface between the aggregate and the cement paste. It is proposed to develop ceramic coatings that facilitate bonding. By working with conventional portland cement, the cement placement techniques do not need to be altered, allowing for wide-spread application of the technology. MS students preferred.

Understanding Morphology Effects on Plasticity in Ceramic Bodies

A new test is being developed, based on specific volume diagrams, that has the potential to explain the packing of shaped particles and how variations in morphology contribute directly to packing efficiency. It is proposed based on a large amount of previous work, that morphology plays a key role in plasticity development in traditional and advanced ceramic systems by controlling the packing behavior on a microscopic level. If this concept proves to be correct, it should be possible to construct plastic bodies and to predict the plastic body performance thus reducing waste in industrial processes and providing for greater quality. MS student preferred.

Strength-Processing Relationships for Ceramic Materials

The strengths of both advanced and traditional ceramic materials are typically approximately 1000 times less than the elastic modulus of the material (E/1000). Recent work indicates that the strength-controlling defects in traditional and advanced ceramic materials are both similar in size and can be directly related to flaws introduced during the processing stage. Of course the chemistry and microstructure of the ceramic material plays an undeniably important role; process improvements are necessary to attain the strength potential of ceramics. This investigation will directly evaluate the relationship between processing and strength assessing the role of mixing and the performance of processing additives. Both MS and PhD students will be considered.

Ceramic Processing and Characterization

Collaboration with industry is central to the mission of the Center for Advanced Ceramic Technology and the New York State College of Ceramics. Students will gain experience in ceramics processing, manufacturing, and characterization with an emphasis on meeting the needs of the industry sponsor. MS students preferred.

Ceramic Thin-Film Deposition

Novel-ceramic thin films will be deposited via ion-assisted electron beam, pulsed DC sputtering and/or RF aerosol mist technique. Films will be characterized by SEM/EDS, XPS, TEM, XRD and/or other measurements. MS students preferred.

Gas Separation Membranes

Possible new power plant designs include gas separation membranes that can reduce CO2, oxygen, or hydrogen, but the technology is still not mature. A study of a novel process for producing gas separation membranes is available. The work centers on creating mesoporous oxides of Ni, Si, Al, etc. and subsequent evaluation of the membranes that will provide the basis for possible widespread applications.

Nanoscale Layered Photocatalysts

Layered oxide ceramics are under study for hydrogen production and/or water and air purification. The layered materials provide a different means of adjusting the bond lengths and local coordination around the catalytically active cations. Extensive experimental work will focus on synthesis and both study of the structures and catalytic activity.

Fuel Cell Cathodes

Improved cathodes for solid oxide fuel cells that can tolerate the demands of metal support structures and industrial fuels are critical for commercialization. We anticipate a large centered-on discovery of new materials that are both catalytically active and stable in the fuel cell environment. Extensive crystal chemistry and in-situ analysis will be important in the anticipated project.

Oxide-Supported Metal Catalysts

Improved catalysts for producing hydrogen from various hydrocarbons may lead to the realization of environmentally-friendly hydrogen fuels.

Thermo-Responses Polymers

Fiber optic guided near infrared (NIR) laser radiation can induce photothermal phase transitions in thermo-reversible polymers. Our method for inducing the phase transition is new and can be considered for biophotonic applications including its use in biosensors, drug delivery media, and bioseparation devices. However, biological species are temperature sensitive and slight fluctuations can lead to loss of life or function of the species through cellular damage or protein denaturing. Therefore it is important to establish, predict and control the thermal profile associated with localized heating of water by the fiber optic laser. By having a complete understanding of the thermal behavior as a function of laser power we can find the right combination of biomolecule and application. We intend to model the convective and conductive heat transfer near the fiber tip and correlate the modeled results to measured data displaying the true temperature profile. Our work would be the first to establish the thermal profiles as well as convective currents associated with laser-induced phase changes in PNIPAM. This work would also set the precedence for research coupling laser-induced phase changes in PNIPAM with biological systems.

Osteoblast Stimulation by Bioactive Glasses

Calcium phosphate-containing bioactive glasses react with aqueous solutions and can bond with bone tissue. Additionally these glasses can stimulate genuine bone matrix deposition by osteoblasts. Current research focuses on determining which compositions induce the greatest response, including the possible addition of trace metals to further stimulate osteoblast activity. MS student with biological background preferred.

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Future use of carbon-based fuels, including biofuels, will require new gas separation technologies to extract the high value gasses (hydrogen) from the greenhouse gasses. High stability oxide ceramics for separating gasses based upon molecular mass may become a technologically feasible alternative to cryogenic gas separation. Advanced nano-scale materials design and processing is required to develop new solutions for gas separation.