Syntactic Selective Near Infrared Scattering Architectural Coatings

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Abstract

P3 Awards: A National Student Design Competition for Sustainability
Focusing on People, Prosperity and the Planet.
Funding opportunity number EPA-G2008-P3-Z3 – Energy

Syntactic Selective Near Infrared Scattering Architectural Coatings

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Institution:
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Student Represented Departments:
Department of Materials Science and Engineering, Drexel University
http://materials.drexel.edu

Project Period:
Phase One: start date August 4, 2008, end date April 1, 2009

Project Amount:
$9,999

Project Summary:
Solar Gain is in part responsible for up to 56% of energy consumed by cooling systems in residential buildings.[1] By reflecting and scattering radiant energy from the sun, the surface temperature of exterior walls and roofs can be greatly reduced. Previous studies have indicated that although TiO_2 based white paints are highly efficient at scattering visible light, absorption occurs for wavelengths of 650nm and higher.[4] A coating utilizing a filler with a broad particle size distribution will reflect solar radiation from a broad range of wavelengths. Preliminary data suggests that glass hollow microspheres are the ideal candidate for scattering light from the visible region well into the near infrared region. Glass hollow microspheres are easily integrated into traditional binder systems such as acrylic or latex base, are fire retardant, and manufactured from inorganic commodity raw materials. By optimizing the particle size distribution and packing factor of the glass hollow microspheres, highly efficient, low solar gain coatings are possible. Optimization of the coating will involve a thorough analysis and characterization of starting material blends, characterization of mixed coatings and microstructural characterization of dried coatings.

Supplemental Keywords:
Syntactic coating, close packed hollow microspheres, Qcel, NIR reflective glazing, solar gain

Research Plan
Introduction

Buildings consume 40% of the primary energy in the United States, out of which, on average 13% is from cooling loads annually.[1] Heat gains due to walls, windows, and roofs account for 56% of energy consumed by cooling systems in residential buildings.[1] Therefore, solar gains greatly contribute to the amount of energy consumed by buildings. By properly shielding a building from solar heat gain, the cooling load of a building can be reduced, yielding energy savings.

Radiation transmitted by the sun can be broken into three basic components; ultra violet, visible, and near infrared. Each of these regions corresponds to a particular wavelength of light, with the UV and visible regions being particularly narrow. Although much energy is transmitted by the UV and Visible regions, the near infrared (NIR) region is comparatively much wider in wavelength, therefore having a larger contribution to thermal gain than UV and Visible combined[2] (Figure 1).

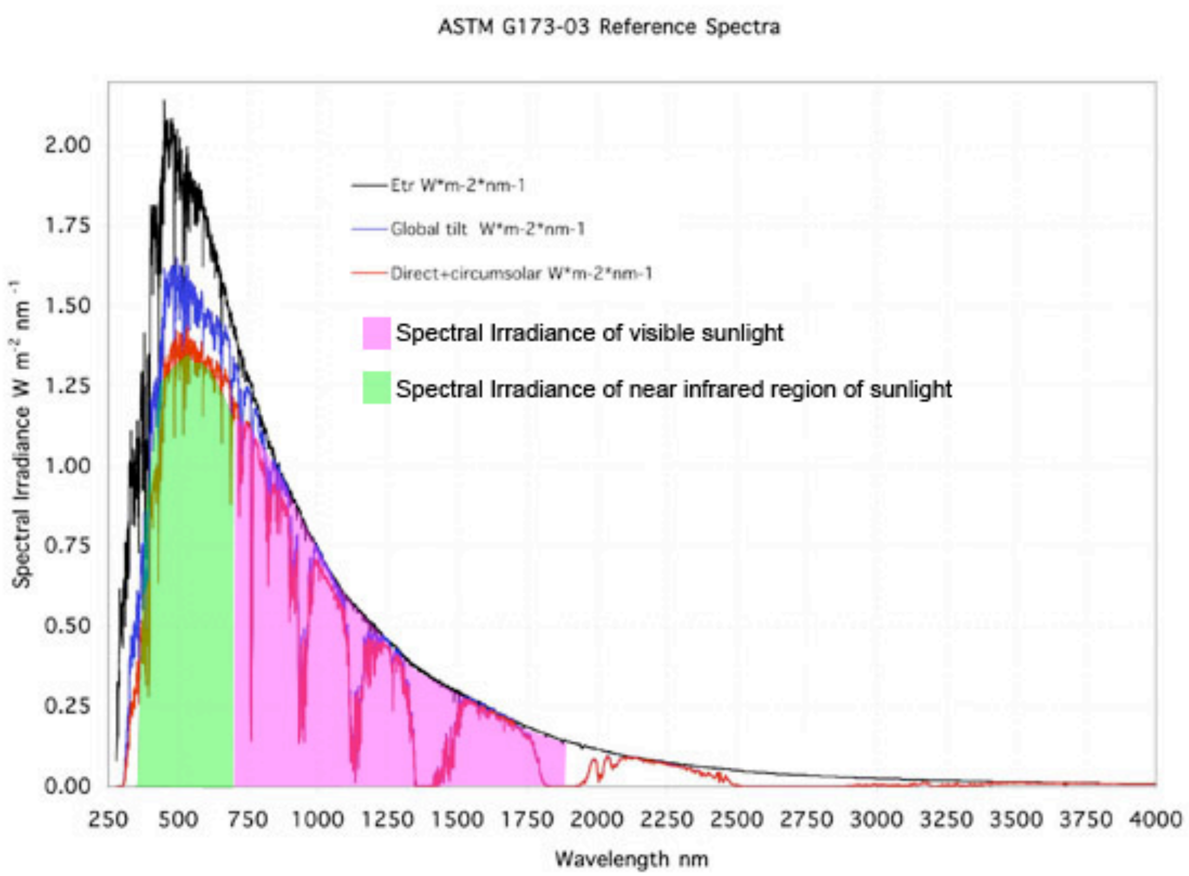

Figure 1: Spectral Irradiance of sunlight, according to ASTM G173-03 AM1.5[2]
Shaded regions indicate visible and infrared regions.

Traditionally, little thought is given to infrared scattering properties of paints and coatings. Titanium dioxide is used in most paints as the primary pigment due to it's hiding power[3]. Titanium dioxide particles lend their hiding power to TiO2's particularly high refractive index, which is controlled by grinding the TiO_2 to an optimal particle size. Titanium dioxide particles are ground to an optimal particle size of about half the wavelength of visible light, or 0.2-0.4µm. Below this size, the particles loose their scattering ability; above it they loose their hiding power[3].

Previous studies have indicated that although TiO_2 based white paints are highly efficient at scattering visible light, absorption occurs for wavelengths of 650nm and higher (Figure 2)[4]. This data clearly indicates that common commercially available paints, which are exclusively TiO_2 based, do not effectively reflect or scatter NIR radiation. Absorption that occurs in the NIR region is realized in the form of heat at the surface of the coating.

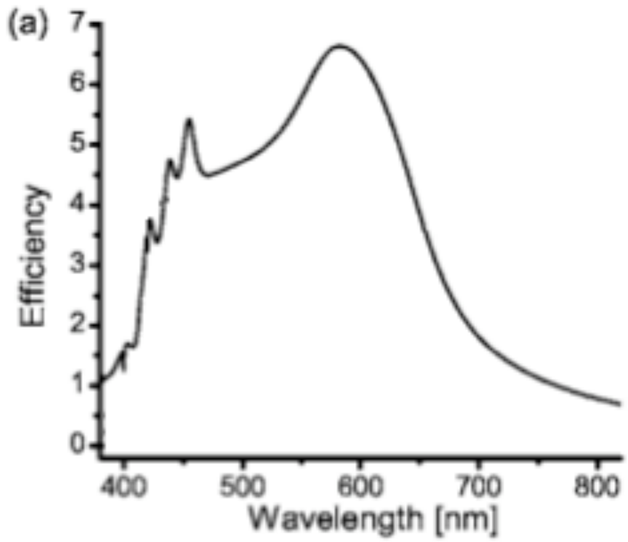

Figure 2: Scattering efficiency of titanium dioxide nanoparticles[4]

Scattering of one particular wavelength of light can be modeled my Mie Theory. Mie Theory predicts the optimal particle diameter needed to scatter one wavelength of light.[5] By extending this prediction across the entire near infrared spectrum, a particle size distribution can be predicted for ideal scattering in the near infrared region. A filler with the proper particle size distribution can be homogeneously mixed into a transparent binder system to create a coating with a close packed microstructure. Given ideal conditions, when a light wave of wavelength λ hits the coating, it will pass through various particles until it is deflected by a particle of ideal diameter for scattering.

Challenge Definition

In order to design an architectural coating capable of scattering and reflecting UV, Visible, and NIR radiation from the sun, the filler (scattering) particles must be optimized for full spectrum scattering. By using Mie Theory as a basis for optimal particle size necessary to scatter a particular wavelength, a filler medium with preferred optical properties will be designed to encompass a corresponding particle size distribution, based on wavelengths to be scattered.[5] The filler medium, or filler particles will be bound by conventional binder systems such as latex or acrylic.

Innovation

Hollow Microspheres: Introduction

Hollow Microspheres (HMS) are a class of material derived from fly ash from coal fired power plants. Materials formulated with HMS are referred to as Syntactic. These HMS powders find their way into many commercial products including thermal insulation for offshore sub-sea oil delivery lines. The utility in the insulating application is not only density reduction and thermal insulation of the pipe wall, but also the ability of the insulating layer to withstand high pressures at depth. In the Building Products industry, the use of HMS in insulating roof coatings has received attention in recent years.[5]

One product in particular, Hy-Tech Thermal Solutions Insulating Ceramics, uses low thermal conductivity ceramic hollow microspheres to increase the insulation factor, or R value, of a coating.[6] The addition of these spheres is done only to decrease the coating's thermal conductivity; no selective optical scattering takes place since the particles are opaque and their size distribution is not tailored for optical scattering events.

Hollow Microspheres: Our implementation

Spherical micro and nanoparticles such as glass hollow microspheres are ideal for scattering of NIR radiation due to their spherical geometry which allows for interaction with incident light of any polarization.[4] By suspending these glass hollow microspheres at high volume fraction in a binder system such as acrylic or latex, a coating which dries into a close packed glass hollow microsphere layer is possible. This coating can then be applied to a substrate and take full advantage of the bulk optical properties of the glass hollow microspheres.

Glass hollow microspheres of compositions of sodium borasilicate will be used for this research; their optical properties and presence of air gap voids at the centers of the spheres make them ideal candidates for visible and NIR scattering. Durability of the final coating should be comparable to or better than that of the binder system used.

Initial research was conducted by a team of undergraduate students at Drexel University under the direction of Dr. James Hagarman. These trials utilized off the shelf products from PQ Corporation and 3M Corporation. See the attached supporting letter for a brief account of materials, methods, and results of the trials.[7]

Methods:

Previous work conducted at Drexel University provides strong supporting evidence that glass hollow microspheres are a viable scattering filler capable of reducing a coating's temperature under sunlight compared to titanium dioxide based coatings. The research team assembled will formulate a theoretical model for the scattering and optical interactions with glass hollow microspheres, conduct in depth simulation trials, characterize optical and microstructure properties of coatings and raw materials, and optimize the filler particle size distribution. Further work done on this project, budget permitting, includes field testing an optimized coating on an experimental property at Drexel University outfitted with proper measurement facilities.

Material Characterization

Photon Correlation Spectroscopy will be used to evaluate the exact particle size distribution of glass hollow microspheres in given samples. Fourier transform infrared spectroscopy (FTIR) will be used as a qualitative investigative tool into the optical properties of different glass hollow microsphere samples. Further optical testing methods will be investigated by the research team as necessary.

Coating Characterization

Since the formulation goal of the architectural coating is to achieve close packing among the glass hollow microspheres, several microscopy techniques will be employed to monitor close packing efficacy. Our primary method of obtaining inexpensive, quick results will be to freeze and fracture a dried, coated substrate with liquid nitrogen, then use SEM to characterize the microstructure of the fractured coating surfaces. This method provides a glimpse of the cross section of a coating.

Project's role in education:

Work conducted on Architectural Coatings will ultimately be featured in a permanent, evolving display of sustainable research and technology at Drexel University called the Drexel Smart House.

The Drexel Smart House is a student-led, multidisciplinary project to construct an urban home to serve as a "living laboratory" for exploring cutting edge design and technology. Participants will conduct research and develop designs in the areas of environment, energy, interaction, health, and lifestyle with the ultimate goal of improving quality of life in the urban residential setting. The project will provide an outstanding example for what the urban home of the future should look like and will show how quality of life can improve through smart design and technology: simplifying daily life, decreasing a person's environmental impact, and providing a healthier home.[8]

The Smart House project is currently in the design phase, however construction is scheduled to begin at the end of 2009. Located at 35th and Race Streets in Philadelphia, the Drexel Smart House aims to educate the Philadelphia community, Drexel University students, other universities, and the public about sustainable practices and technology in a real world setting. When completed, the home will be a permanent, evolving icon of sustainability in Philadelphia designed to house ten students.

The research community at Drexel University, particularly the personnel in the Drexel Nanotechnology Institute, will see first hand how materials and nano materials research can be applied to develop sustainable products and technologies. The undergraduate students on the Architectural Coatings research team (Eric Eisele, Sarah Byrnes, Charlie Woods, and Dan Pugh) will complete their Senior Design Theses for Bachelor of Science degrees in Materials Science and Engineering.

Project Schedule

July 2008
- •Finalize background research
- •Finalize market & economic analysis

August 2008
- •Finalize theoretical model & Mie theory calculations
- •Calculate optimal particle size distribution data
- •Evaluate all potential binder products, select binder materials for trials

September 2008
- •Present proposal to Engineering Design Panel (University degree program obligations)
- •Obtain panel of glass hollow microsphere samples from PQ Industries
- •Conduct optical analysis on glass hollow microsphere samples
- •Blend samples based on calculations from theoretical model
- •Coat substrates for sunlight simulation tests

October 2008
- •Conduct detailed characterization of top performing samples
- •Duplicate results of top performing samples
- •Prepare samples for long term testing
- •Formulate mechanical testing methods for durability, frictional characteristics, wear resistance

November 2008
- •Begin long term testing of samples
- •Conduct mechanical testing
- •Begin research on additional pigmentation systems

December 2008
- •Research ASTM and other industry standards for market viability
- •Begin provisional patent disclosure process

February 2009
- •Conclude coating foundtion formulation
- •Continue pigmentation research & testing

March 2009
- •Identify continuing research and commercialization costs

April 2009
- •Prepare final report for P3 Award
- •Prepare for phase two of P3 Award

Partnerships

- •Verbal commitment from PQ Industries, manufacturer of glass hollow microspheres
  - •Will donate samples and provide product technical support
  - •Possibility for fund matching will be discussed for phase two of P3 award
- •At this time, no other partnerships are anticipated.

References

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[3]J. Beltley and G. P. A. Turner, Introduction to Paint Chemistry and Principles of Paint Technology, 4th ed. (Chapman and Hall, London, 1998), p. 105-106, 110.

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[5]G. Mie, Ann. Phys. 25, 377 1908 ; C. F. Bohren and D. R. Huffman, Absorption and Scattering of Light by Small Particles Wiley, New York, 1983 , p. 82.

[6]Hy-Tech Thermal Solutions product website http://www.hytechsales.com/insulating_paint_additives.html

[7]Hagarman, James. Letter – Email Communication with Eric Eisele. July 6, 2007

[8]Drexel Smart House Student Organization, Drexel University http://drexel.edu/smarthouse

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December 19, 2007

To Whom It May Concern:

I am submitting a proposal for a grant from the Environmental Protection Agency for a project called Architectural Coatings. Architectural Coatings utilize a glass hollow microsphere (borosilicate and aluminosilicate) filled acrylic base coating to selectively scatter and reflect near infrared radiation from the sun based on Mie Scattering theory.

Enclosed please find my Curriculum Vitae and a statement of Current and Pending Support.

If you require any additional information, please feel free to contact me.

Dr. Michel Barsoum
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December 19, 2007

To Whom It May Concern:

Architectural coatings with visible and near-IR reflectivity in thin, multilayer films. Coatings use commercial raw materials from Rohm and Haas Co., PQ Corporation, 3M Co. and Emerson Cuming Composite Materials in Canton, Mass. Coatings use standard manufacturing technology and are applied by conventional techniques in use in the industry. Acrylic latex binders are filled with hollow glass microspheres to produce such efficient coatings.

We plan to save 10% of the annual energy cost in cooling season by saving 40% of the air conditioning costs of 10% of the building infrastructure in-place and planned. Building targets are residential and light commercial structures with wood, vinyl, or stucco exteriors and trim.

We further intend these coatings to be fire-retardant due to the inclusion of special hollow glass microspheres with high ignition moisture content and low softening temperature. Still further, we intend these coatings to be acoustically insulating as tested by the Non-Destructive Testing Facility at Drexel in the Applied Engineering Technology program.

As such, with the combination of thermal and acoustical properties, these thin coatings can also be applied to fabrics suitable for temporary inflatable structures intended for emergency relief or inhospitable environments.

This work will be performed as Undergraduate Research by Applied Engineering Technology students using the extant Measurements Lab and Non- Destructive Testing Facility at Goodwin College/Drexel University in combination with Smart House.

James A. Hagarman, Ph.D.
Program Manager
Corporate Onsite and Online Programs
Goodwin College
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215-895-0909

Supporting Letter: Syntactic Architectural Coatings Research
Dr. James Hagarman

Materials and Methods: Representative samples of HMS and latex binders were obtained from commercial sources and simple three-part coatings were formulated to stucco-like (trowelable) consistency. A spreadsheet was constructed for all formulations to allow calculation of total solids and volume loading of HMS in the formulations. Coatings (one and two layers) were troweled onto 3/8 plywood (12in.X 12in.) panels. Wet and dry coated panel weights, combined with solids content, allowed calculation of coating thicknesses. Coated panels were exposed to heat lamp radiation at several distances (one foot and two feet) and the front and back panel temperatures were measured by several techniques. The large number of panels was first measured for surface temperature during heating with an optical pyrometer. The most interesting coatings were then re-evaluted using thermocouples linked to a real-time data acquisition system (Lab View). For each coating, the pyrometer data was correlated to the thermocouples by adjusting the emissivity of the pyrometer. Estimates of emissivity of each coating were thus obtained. The best coatings were compared to white paint and grey paint over a 30 minute heating period sampling front and back surface temperatures every 30 seconds, following by a cooling period sufficient to return to near-ambient temperature (80 deg F). These measurements were taken for both single and double layer coatings at distances (lamp to panel) of one and two feet.

Results: Peak temperatures of approx. 150 deg F and 120 deg F were obtained for grey and white paint. The best of the HMS coatings (3M S-60) peaked at approx. 105 deg F. This HMS coating was 15 deg F cooler than the white paint, roughly 38% reduction in temperature rise over ambient (80 deg F) compared to the white control. The relative efficiency of the HMS coatings is related to the size distribution of the HMS (smaller is generally more efficient). The difference between the single and double coats for various HMS is small compared to the absolute effect. The ceramic HMS (flyash-derived) were the poorest performers among the HMS. No attempt was made to improve the color of the flyash coatings which was noticeably grey-brown.

Discussion: If we consider that roughly 45% of the solar heating effect is from visible light and roughly 50% is from near-IR, and we consider that grey paint and white paint peak in our experiments at 150 and 120 deg F, we might roughly expect efficient near-IR scattering to be able to reduce surface temperatures approx. 30 deg F. The coatings prepared in this study have realized approx. ½ of the maximum expected thermal cooling- 15 deg F. Considering further that the HMS size distributions truncate, in the best case, at one micron, and realizing that approx ½ of the incident near-IR solar radiation is in the region 700 nanometer to one micron, we might expect that extending the size distribution of the HMS in such coatings to 700 nanometers could effect an improvement in overall cooling efficiency.

Since we have observed only a small effect in cooling efficiency upon increasing HMS coating thickness by an order of magnitude (from approx. 20 microns to 40 microns), it is conjectured that the observed HMS effect is not conventional foam insulation- whereby the density reduction and trapping of contained air reduces the thermal convective heat transfer, but rather a scattering effect which keeps the heat out of the thermal mass of the wall completely. As mentioned above this shortens the cooling period for such a wall in the cool evening and reduces the late-day time lag between exterior and interior areas. In fact, the density of the most efficient HMS is little different that the latex binder system. Such coatings- provided gas entrainment is controlled during formulation- are about 1.0 in specific gravity. Some of the less efficient HMS are significantly lighter than the better HMS- producing lower density coatings. If conventional insulative effect were dominant the results should be reversed. Also and last, the PQ product 1.10P8, while the smallest HMS in the study, is only second in efficiency as insulation. Discussions with PQ Corp. have indicated that the fines portion of this product is solid, not hollow, microspheres. Perhaps at least a portion of the insulating effect with HMS is due to refraction of the incident radiation as the hollows have a void with a significantly different index of refraction that either the latex binder or glass HMS wall.

Budget

$1870	Domestic Travel to Washington D.C.
$2398	Supplies
$2398	Characterization costs
$3333	Indirect costs
$9999	Total Project Cost

Budget Justification

Domestic Travel: Travel cost were estimated for the trip to the National Sustainable Design Expo. Roundtrip Amtrak fare from Philadelphia to Washington D.C. is currently $84. We assumed that the fare might increase slightly before the next expo. We assume $95 for the purpose of our calculations. We estimate that six people will be attending bringing the total travel fare to $570. Checking rates online, it appears that a room for three people near the National Mall will be approximately $325 per night. Two rooms for two nights at $325 comes to $1300. The total for travel cost comes to $1870.

Supplies: For trials, general hardware and supplies must be purchased such as thermocouples, substrates, heat lamps, isolation boxes, sample holders, etc. Data capturing and logging equipment will be provided courtesy of Drexel University AET Labs. Glass hollow microspheres will be supplied either in bulk at no charge by PQ Industries, or in smaller quantities from 3M. Binder materials will be supplied at no charge by various manufacturers by requesting product samples; a common practice in industry. Quantity of samples supplied by manufacturers will be sufficient for our purposes.

Characterization Costs: In order to verify particle size distribution of starting materials, Photon Correlation Spectroscopy and other characterization methods must be employed. Scanning Electron Microscopy will be used to determine close packing quality of microspheres. Lateral Force Microscopy will be one among several mechanical material tests used to determine wear properties of the coating. Several spectroscopy methods and optical tests will be used to determine the emissivity of the coatings. Each of these procedures will take place in the Materials Characterization Facility and Drexel Nanotechnology Institute at Drexel University, billed on an hourly basis.

Indirect Costs: Based on the standard accounting practice of Drexel University, 50% of the total direct cost was used to calculate the indirect costs.

1. **Name and Academic Rank**: Michel Barsoum, Distinguished Professor.

2. **Degrees:**
- B.Sc. (hons) Materials Engineering, American Univ. in Cairo, Egypt, 1977.
- M.Sc. Dept. of Ceramics Eng., Univ. of Missouri-Rolla, Rolla, MO, 1979.
- Ph.D. Dept. of Materials Science and Engineering, MIT, Boston, MA, 1985.

3. **Professional Experience**: 21 years; Original Appointment: September 1985.

Drexel University:
- 1999-current Distinguished Professor
- 2000-2001 Sabbatical Leave, Max-Planck Institute, Stuttgart, Germany
- 1997-1999 Professor
- 1994-1997 Associate Professor
- 1993-94 Sabbatical Leave, Max-Planck Institute, Stuttgart, Germany.
- 1990-93 Associate Professor
- 1985-90 Assistant Professor

4. Other Related Experience:
- Instructor for MATE-340 Fundamentals of Ceramics, (Fall 2006).
- Principal Instructor for tDEC-211 (roughly once per year – most recently Fall 2005).
- Instructor for MatE-580 Graduate Class on *Intro. Solid State Materials*, Fall 2006.
- Instructor for MatE-580 Graduate Class on *High Temp. Materials*, Winter 2006.
- Freshman Design Advisor; Senior Design Advisor.

5. Consulting:
- CEA, Paris, France (2006 to date).• 3-ONE-2, Voorhees, NJ (2004 to date).

6. States in which Registered: N/A

7. Principal Publications of the last five years:
Textbook: Fundamentals of Ceramics, (668 pages, 300 illustrations), Francis & Taylor, NY, 2003.

Published > 85 refereed papers during the 2001-06 period; ~12 currently under review; 14 patents.

1. M. W. Barsoum, "Nanolayered Kinking Nonlinear Elastic Solids", Handbook of Nanomaterials, Ed. Y. Gogotsi, CRC Press, 2006.
2. M. W. Barsoum "Physical Properties of the MAX Phases", Encyclopedia of Mat. Sci. and Tech., Eds. K. H. J. Buschow, et al, Amsterdam, 2006.
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8. Scientific and Professional Societies:

- Member of American Ceramic Society, MRS and APS.

9. Honors and Awards:

- Academician, World Academy of Ceramics, 2006.
- Fellow, American Ceramic Society, 2005.
- Marquis Who's Who in Science and Engineering, 2005-2006 Ed.
- Department of Materials Science and Engineering, Outstanding Research Award, 2003.
- Visiting Professorship, U. of Poitiers, Poitiers, France, 2003.
- College of Engineering Outstanding Research Award, 2003.
- Research Scholar Award, Drexel University, 2001.
- Alexander von Humboldt-Max Planck Society Prize for Senior US Scientists, 2000.
- Distinguished Professor, Drexel University, 1999.

10. Institutional and professional service (last five years):

- Chair of Departmental Tenure and Promotions Committee (2000- date).
- Member of College of Engineering tDEC Committee; University Sabbatical Committee.
- Reviewed papers for over a dozen Journals.
- Reviewed proposals for NSF and U.S. Civilian Research & Development Foundation (CRDF).
- Organized Departmental Seminar Series (Fall 2005).

11. Professional Development Activities (last five years). None.

James A. Hagarman, Ph.D.

Program Manager
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EDUCATION

B. S. Chemistry, Carnegie-Mellon University 1966
Ph.D. Inorganic Chemistry, Villanova University 1975

WORK HISTORY

PRESIDENT, THERMACELL TECHNOLOGIES, INC., Daytona Beach, FL 2000 – 2002

Responsible for development of a new business enterprise in specialty chemicals. Organized technology, manufacturing and sales in order to build a business in functional fillers. Carried out research to form basis of technology for new product set. Extended pilot scale technology through full scale plant construction and commission. Developed a new set of hollow nano/microsphere products which have been marketed to the bowling ball, building products and FRP industries. Focus application was in architectural coatings (roof and house coatings and paint). In particular, TiO2 replacement for opacity and hiding power was combined with insulating utility in the near-IR portion of the solar spectrum.

Novel properties of hollow nano/microsphere products include small particle size with significant populations below 20 microns. Special additives to aqueous feed solutions provide long-term storage stability to the feed and inertness of the finished product in a wide range of binder systems, including thermosets and latex.

DIRECTOR OF TECHNOLOGY, EMERSON & CUMINGS COMPOSITE MATERIALS, CANTON, MA. 1999 - 2000

Oversaw all aspects of sub-sea syntactic buoyancy and insulation. Responsibilities include Environmental Health and Safety, Quality Control and Quality Assurance, Engineering Design and Research and Development.

Technical applications for the business included development, manufacturing and testing of hollow microsphere-filled epoxy bouyancy modules and thermal insulation for subsea oil well drilling and development. Syntactic epoxy foams were also designed and tested for ablative coatings for NASA and for bouyancy modification of nuclear submarines for the U.S. Navy.

BUSINESS MANAGER, NORTH AMERICA, HOLLOW MICROSPHERES BUSINESS, SPECIALTY CHEMICALS DIVISION, P Q CORPORATION VALLEY FORGE, PA. 1996-1999

Complete income statement responsibility for North American (including Mexico and Canada) functional fillers business. Sales grew from $4 to $22 Million with major additions to body putty and explosives markets in the US and Mexico. Managed market development in cosmetics, friction materials and refractory applications. Negotiated purchase/resale of business with special ceramic microsphere products from Australia and plastic products from Japan and Sweden. Responsibilities included management of R&D and Sales as well as product management for International Sales from plants in the US.

PRODUCT / MARKETING MANAGER, HOLLOW MICROSPHERES BUSINESS, SPECIALTY CHEMICALS DIVISION, P Q CORPORATION , VALLEY FORGE, PA. 1988-1996

Managed hollow glass and ceramic microsphere product line. Responsible for market development, product quality, pricing, promotion, and product development program. Managed design and startup of second glass microsphere-manufacturing facility in Augusta, Ga. Managed ISO 9002 certification of both glass and ceramic plants. Drove growth in autobody filler and explosive sensitization applications and entry into cosmetics, refractories, friction materials, building products, automotive sealers and marine coring applications. Patent 4,983,550 awarded for hollow nano/microsphere with 8 micron mean size.

R&D MANAGER , HOLLOW MICROSPHERES BUSINESS, SPECIALTY CHEMICALS DIVISION, P Q CORPORATION , VALLEY FORGE, PA. 1984-1988

Managed Process and Product Development, Applications Development and Technical Service for hollow spheres business. Instituted technology changes in manufacturing process and associated product quality improvements for hollow spheres product line.

PROJECT SCIENTIST, CALOCERINOS & SPINA CONSULTING ENGINEERS, SYRACUSE, NY 1978-1984

Project manager for consulting contracts in Water Resources Planning and Solid Waste Management in Syracuse, NY and Binghamton, NY. Work encompassed Combined Sewer Overflow planning for municipalities, Hazardous Waste Landfill permitting for private industry and Sewage Sludge Management permitting for municipalities.

CHIEF, WATER RESOURCES PLANNING, UNIVERSITY CITY SCIENCE CENTER, PHILADELPHIA, PA. 1973-1978

Managed USEPA Contract: Dissemination and User Assistance for the Storm Water Management Model. Negotiated and managed consulting contracts for modeling assistance in Water Resources Planning in Philadelphia, Pa., Richmond, Va., and Binghamton, NY.

CHEMIST, ROHM & HAAS ,PHILADELPHIA, PA. 1966-1970 .

Research and Development Chemist in pulp and paper laboratory. Developed acrylic latex binders for paper coatings and acrylic solution polymers for wet-end fines retention. Conducted commercial trials of new products with customers in the pulp and paper industry.

Eric Eisele

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Website: **http://www.pages.drexel.edu/~eje82/**

Education

Drexel University College of Engineering
Bachelor of Science in Materials Engineering, Anticipated Graduation - June, 2009

Engineering Coursework

Organic Chemistry, Engineering Ethics, Microstructure of Metallic Materials, Transport Phenomena, Thermodynamics of Materials, Kinetics of Materials, Processing of Polymers, Advanced Materials Lab

Experience

DuPont

- Researched novel purification techniques for the commercial production of organic semiconductors for OLED display development
- Provided evaluation and support for newly implemented processes in a scale up research lab

Drexel Smart House Student Organization at Drexel University

- Vice President, Director of research for the Drexel University Smart House Project
- Co-Founded research driven multidiscipline student organization in February, 2006
- Procures resources, grants, and other funds for Student Organization; leads student design and research groups on goal oriented projects

Drexel University Department of Materials Science and Engineering

- Conducts research with graduate students for Prof. Michel Barsoum's MAX Phase Group
- Received training and certification for characterization facilities; Experienced with SEM, AFM, LFM, Nanoindentation, and Nanomanipulation

Cognis Corporation

- Conducted polymer formulation and synthesis, participated in new product development and product revolution for a multinational specialty chemical corporation
- Interfaced directly with Senior developers and designed starting point formulations for scale up and mass production in the polymer inks, coatings, and adhesives industry

Computer Skills

Experienced with MS Office, AutoCad, LabView, Maple, and KaleiaGraph. Some experience in C, HTML, CSS, PHP, and JavaScript. Proficient in both Windows and Mac OS X.

Achievements and Honors:

- Drexel Smart House – Executive Board Member and Co-Founder
- Materials Science and Engineering Research Position – February, 2005 - Current
- Published in the Journal of the Transportation Research Board – April, 2006
- Bronze Medal – Delaware Valley Science Fairs 2003 - Full tuition scholarship - ***Drexel University***
- Most Outstanding Engineering Research Project - ***Yale Science & Engineering Association*** 2003

Charlie Woods
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charles.kyle.woods@drexel.edu

Education

Drexel University, Philadelphia, PA
Bachelor of Science in Materials Engineering, Anticipated Graduation - June, 2009
Cumulative GPA: 2.82

Experience

Stonhard, Maple Shade, NJ
Tech Service Lab Coop, April to September, 2007
Created custom color polymer resins
Performed bond strength tests
Performed diffuse reflectance tests to determine chemical composistion
Weighted Calcium Chloride test to determine moisture concentrations
Wrote reports about test results

SYSTRA Consulting, Philadelphia, PA
Intern, April 2006 to March 2007
- Created and modified CAD drawings including site plans, elevations and details
- Logged, processed and filed all CRS material for multiple projects
- Used MS Excel to track submittals and RFIs
- Distributed submittals and RFIs to appropriate people for review
- Forwarded completed submittals and RFIs to the client
- Gathered information for use in proposals

EV Custom Systems, Mine Hill, NJ
Computer Technician, July to September, 2005
- Built and configured custom computers
- Removed spyware and viruses
- Identified and remedied software and hardware problems.

Freshman Design Project

- Developed a new way to cool computers
- Worked in a team of three
- Over 40 hours of research and design meetings
- Wrote an extensive final report and gave an accompanying PowerPoint presentation

Skills

- Familiar with Microsoft Word, Excel, PowerPoint, and the Windows operating system family
- Proficient with CAD software: Pro/DESKTOP, AutoCAD, Chief Architect, and Cinema 4D
- Familiar with Construction Related Services including Submittals and Request For Information
- Experience with testing of material's properties including: tensile tests using an Instron, charpy impact testing, and Rockwell hardness testing

Relevant Coursework

Systems I, II
Organic Chemistry I
Materials I
Microstructure of Metallic Materials
Introduction to Polymers
Kinetics of Materials
Biomedical Materials
Engineering Computational Laboratory

Energy I,II
Linear Algebra
Introduction to Mechanical Properties of Materials
Processing Metallic Materials
Thermodynamics of Materials
Transport Phenomena
Advanced Materials Laboratory

Honors and Awards

- First Place in CAD Engineering event at the 2002 TSA State Conference
- Second Place in CAD Engineering event at the 2002 TSA National Conference
- First Place in CAD Engineering event at the 2003 TSA State Conference
- Second Place in CAD Engineering event at the 2003 TSA National Conference

Sarah M Byrnes
410 N 32nd St
Philadelphia, PA 19104
sarah.marie.byrnes@drexel.edu

Education

Drexel University, Philadelphia, PA
Bachelor of Science in Materials Science Engineering, Anticipated Graduation - June, 2009

Relevant Coursework

Systems I, II
Engineering Ethics
Organic Chemistry
Processing of Ceramics
Thermodynamics of Materials
Processing Metallic Materials
Statistical Analysis of Engineering Systems
Biomedical Materials
Physical Chemistry
Energy I, II
Materials I, II
Evaluation/Presentation of Experimental Data
Processing Polymers
Metallic Microstructure of Materials
Linear Algebra
Kinetics
Transport Phenomena
Advanced Materials Laboratory

Experience

Cognis Corporation, Ambler, PA
Functional Products Coop, March to September, 2007
- Synthesized thermoplastic resins
- Evaluated material properties of products
- Installed and implemented new equipment
- Developed procedures to test for defects in products
- Performed dynamic and static surface tension testing
- Developed new products
- Trained employees in the operation of new equipment

Philadelphia Water Department, Center City
Industrial Waste Unit Coop, April to September, 2006
- Wrote and managed Industrial Waste Permits
- Inspected industrial and commercial facilities
- Developed computer applications related to pretreatment
- Researched pretreatment and environmental policies
- Compiled monthly reports
- Presented updates at managerial meetings

Teledyne Energy Systems, Hunt Valley, MD
Student Intern, June to September, 2005
- Laboratory Technician - Thermoelectric Materials Lab
- Completed diffusion bonding of thermoelectric material segments
- Insulated completed modules
- Performed nickel plating of couple details
- Assisted with helium leak check non-destructive testing
- Performed resistivity evaluation of thermoelectric material and circuits

Computer Skills

Microsoft Office
Maplesoft
Matlab
AutoCAD
LabVIEW

Engineering Design Project

"Use of Thermoelectric Cooling for the Enhancement of Laptop Computer Performance"
Worked with a team to write proposals and reports
Consulted weekly with an advisor on procedures and deadlines
Final report consisted of CAD drawings, graphs, and a group presentation

Activities

ASM International
Association for Iron & Steel Technology (AIST)
Society of Women Engineers
American Ceramic Society (ACerS)
The Minerals, Metals and Materials Society (TMS)

Daniel E Pugh
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856-426-1958
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Education

Drexel University, Philadelphia, PA
Bachelor of Science in Materials Science and Engineering, June, 2009
Cumulative GPA: 2.9

Relevant Coursework

Transport Phenomena	Quantum Structure of Materials
Advanced Materials Laboratory	Thermodynamics of Materials
Micro Metallic Materials	Mechanical Behavior of Solids
Biomedical Materials	Engineering Ethics
Kinetics of Materials	Processing Metallic Materials
Processing Polymers	Introduction to Polymers

Experience

Siemens Demag Delaval Turbomachinery Inc, Hamilton, NJ
Metallurgy, April to September 2007
- Conducted Rockwell Hardness Testing
- Conducted X-Ray Fluorescence Testing
- Oversaw Magnetic Particle Testing
- Conducted Die Penetrant Testing
- Constructed spreadsheets to interpret test data
- Performed different heat treatments on metals, including austenitizing and tempering, followed by various quench methods
- Mounted and polished samples for microscopy

Siemens Demag Delaval Turbomachinery Inc, Hamilton, NJ
Process Engineer Co-op, April 2006 to September 2006
- Utilized Lean Manufacturing techniques to improve the business
- Prepared improvement tools Microsoft Excel, Visio, Powerpoint, Visual Basic
- Mapped various elements of the business using Value Stream Maps
- Wrote/revised process descriptions
- Developed metrics to measure success

CDI Corporation, Hamilton, NJ
Contractor-Siemens, September 2006 to January 2007; September 2007 to present
- 2006: Identical to Siemens Process Engineering title, continuation after co-op term
- 2007: Identical to Siemens Metallurgy title, continuation after co-op term

Machinery

Instron Tensile Tester	Birnell and Rockwell Hardness Testers
Charpy Impact Tester	Optical Microscope
X-Ray Fluorescence Spectrometer	Fourier Transform Infrared Spectrometer
Differential Scanning Calorimeter	Scanning Tunneling Microscope
Atomic Force Microscope	Scanning Electron Microscope
Raman Spectroscopy	Grinding/Polishing Machine

Computer Skills

Operating Systems: Microsoft Windows XP, Microsoft Windows Vista, Mac OSX Professional
Office Programs: Word, Excel, Visio, Powerpoint, Publisher, Outlook
Other Programs: AutoCAD

Activities

MESPO- Student Chapter
MRS (Materials Research Society)- Student Chapter
Drexel University Roller Hockey Club- Vice President/Treasurer

CURRENT AND PENDING SUPPORT
M. W. BARSOUM

CURRENT SUPPORT:

1) Project Title: *$M_{N+1}AX_N$ Phase Solid Solutions: Unique Opportunities at Engineering Bulk and Surface Properties".* With J. Spanier. S. Lofland and J. Hettinger (Rowan U.)
Source of Support: NSF DMR-FRG – Ceramics Division
Total Award Amount: $ 860,000 Total Award Period Covered: 4 years
Location of Project: Drexel University Duration: 8-05 to 8-09
Person Months Committed to Project: calendar AY 0.0 Summer 0.6

2) Project Title: ″Incipient Kink Bands, Damping, Micro- and Macroyielding of Hexagonal Metals
Source of Support: NSF DMR-SGER – Metals Division
Total Award Amount: $ 140,000 Total Award Period Covered: 2 years
Location of Project: Drexel University Duration: 8-07 to 8-09
Person Months Committed to Project: calendar AY 0.0 Summer 0.6

3) Project Title: "Kinking Nonlinear Elastic Solids for Load Bearing, Damping & Strain Sensing Applications"
With P. Finkel
Source of Support: ARO
Total Award Amount: $ 300,000 Total Award Period Covered: 3 years
Location of Project: Drexel University Duration: 8-07 to 8-10
Person Months Committed to Project: calendar AY 0.0 Summer 0.6

4) Project Title: Acquisition of Equipment to Study Linear and Nonlinear Acoustic Phenomena",
CoPI's: Dr. P. Finkel:
Source of Support: ARO-DURIP Total amount from sponsor = $ 90 K.

PENDING:

1) Proposal Title: *Ion-Exchanged Platinum/Carbide-Derived Carbon Catalysts for the Hydrogen Fuel Cell*
Co-PIs: Elabd , Gogotsi, Yeh (DuPont), Kountz (DuPont)
Source of Support: Department of Energy
Requested Amount: $1,341,955
Submitted: 12/12/06 (Proposed for 3 yrs) Location of Project: Drexel University
Person-Month Per Year Committed to Project: Sumr: 1.0

2) Project Title: "Understanding and Recreation of a 4500 Year Old Reconstituted Limestone″.
Source of Support: NSF DMR-FRG – Ceramics Division
Total Award Amount: $ 373,460 Total Award Period Covered: 3years
Location of Project: Drexel University Duration: 8-08 to 8-11
Person Months Committed to Project: calendar AY 0.0 Summer 0.6