University of Wisconsin
Nanoscale Science and Engineering Center
on Templated Synthesis and Assembly at the Nanoscale

Thrust 1: Directed Assembly of Block Copolymer Materials

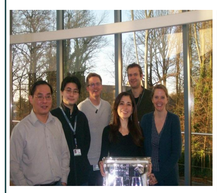
Paul Nealey, Padma Gopalan, Mahesh Mahanthappa, Frank Bates, Juan de Pablo

Thrust 1 explores and develops new materials and processes for advanced lithography, in which self-assembling block copolymers are directed to adopt morphologies that advance the performance of nanomanufacturing processes.

Implementation of the UW DSA at IMEC

B.T. Chan[1], Koichi Matsunaga[2], Todd Younkin[3], Roel Gronheid[1], Kathleen Nafus[2], Paulina Rincon[4], Paul Nealey[4]
[1]Imec Etch, [2]Tokyo Electron, [3]INTEL, [4]Chemical and Biological Engineering, University of Wisconsin, Madison

Imec announces the successful implementation of Self-Assembly (DSA) process line all-under-one-roof in academic lab-scale DSA process flow to fab-compatible Directed Self-Assembly (DSA) process line all-under-one-roof in Imec's 300mm cleanroom fab.



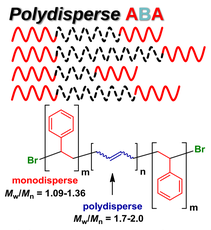
Team members at Imec:
BT Chan, Imec Etch; Koichi Matsunaga, TEL; Todd Younkin, INTEL; Paulina Rincon, UW; Roel Gronheid, Imec; Kathleen Nafus, TEL

UW student - Paulina Rincon

AZ Electronic Materials: Polymers
Tokyo Electron: Track equipment
IMEC:193i litho/etch

Controlled incorporation of Polydisperse Segments into Block Copolymers

Widin, J.M.; Schmitt, A.K.; Schmitt, A.L.; Im, K.; Mahanthappa, M.K.
Department of Chemistry, University of Wisconsin, Madison



poly(styrene-*b*-1,4-butadiene-*b*-styrene) (SBS)

> ***"…we should add mid-block polydispersity to the toolbox of macromolecular architecture variations that allows the synthesis of polymers that have predictable self-assembled structures and useful properties."***
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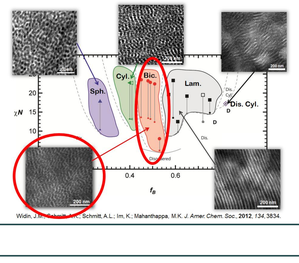
> – R. A. Register, Nature, **2012**, *483*, 167



Widin, J.M.; Schmitt, A.K.; Schmitt, A.L.; Im, K.; Mahanthappa, M.K. *J. Amer. Chem. Soc.*, **2012**, *134*, 3834.

Experimental Phase diagram for poly(styrene-*b*-1,4-butadiene-*b*-styrene) (SBS)

Thrust 2: Sequence-Directed Assembly of Organic Nanostructures

Sam Gellman, Nick Abbott, Juan de Pablo, Song Jin

Thrust 2 explores directed assembly at the nanoscale through the synthesis of biologically-inspired organic nanostructures in which functional side-chains display unique ordering, in terms of both sequence along a backbone and three-dimensional arrangement in space.

Understanding Hydrophobic Interactions on the Nanoscale Using β-peptide Oligomers

Claribel Acevedo, Derek Ma, Sam Gellman and Nicholas Abbott

One vein of research in Thrust 2 uses the predictable, three-dimensional side chain patterns generated by β-peptides in combination with single-molecule force spectroscopy to quantify how changes in nanometer-scale chemical patterns affect intermolecular interactions (and thus sequence-directed assembly). A recent focus has been directed to the question of how proximal charged groups influence hydrophobic interactions on the nano-scale. Theories and simulations have predicted these proximity effects to be significant, but a lack of suitable experimental systems has prevented such ideas from being tested. Exciting results in Thrust 2 reveal that charged (ammonium) groups proximal to a hydrophobic domain do strengthen hydrophobic interactions involving that domain (see Figure). Overall, these results and others are fundamentally changing our understanding of intermolecular forces associated with hydrophobic nanodomains.

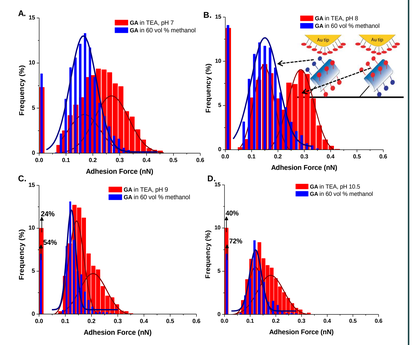


Figure. Force histograms of the **GA** β-peptide oligomer and a hydrophobic AFM tip in TEA buffer and TEA buffer containing 60 vol % of methanol. (A) **GA** in TEA buffer, pH 7. (B) **GA** in TEA buffer, pH 8. Inset shows a schematic illustration of the proposed interaction between **GA** and the hydrophobic tip. (C) **GA** in TEA buffer, pH 9. (D) **GA** in TEA buffer, pH 10.5.

Thrust 3: Driven Assembly at the Nanoscale

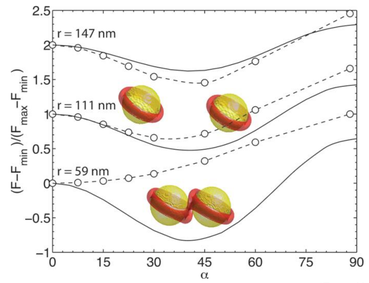
Juan de Pablo, David Schwartz, Nick Abbott

Thrust 3 explores and harnesses non-equilibrium processes, including the use of external fields, for manipulating the assembly of nanoscale objects, including particles and macromolecules.

Liquid Crystal Mediated Interaction Between Nanoparticles

Vivek Tomar, Tyler Roberts, Nicholas Abbott, Juan Hernandez-Ortiz, Juan de Pablo
University of Wisconsin-Madison

Recent research by Thrust 3 has demonstrated that the interactions that arise between nanoparticles suspended in a liquid crystal can be manipulated over multiple orders of magnitude (ranging from 1 to 100 k_BT) through control of the particles' surface chemistry and their radius. Previous work with micron sized particles had established that particle-particle interactions are extremely strong and essentially irreversible. The Thrust's results are significant in that they demonstrate that interactions between *nanoparticles* are fundamentally different from those between *micro*-particles, and they can in principle be controlled to yield reversible, equilibrium assemblies for potential applications in devices.



Potential of mean force for association between two nanoparticles (50 nm diameter) suspended in a nematic liquid crystal. * The approach angle between the Saturn rings and the director is denoted by a. The lines represent a theoretical approximation by Ruhwandl and Terentjev, and the symbols represent full numerical calculations performed by Thrust 3.

*Tomar, V., Roberts, T.F., Abbott, N.L., Hernandez-Ortiz, J.P., de Pablo, J.J., *Langmuir*, in press, 2012

Thrust 4: Environmental Health & Safety Implications of Nanotechnology

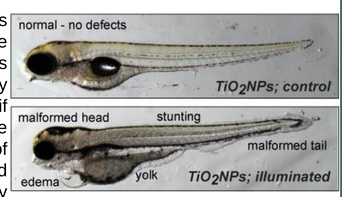
Joel Pederson, Robert Hamers, Richard Peterson, Warren Heideman, Ralph Albrecht

Thrust 4 elucidates the environmental fate and toxicity of nanomaterials.

Phototoxicity of TiO2 Nanoparticles in Zebrafish

Ofek Bar-Ilan, Connie C. Chuang, Denise J. Schwahn, Sarah Yang, Kacie Louis, Joel A. Pedersen and Robert J. Hamers

Nanomaterials offer promise to many pressing problems facing the world. But are these materials safe? The myriad of different shapes, sizes and materials makes testing each material difficult. Concerns about safety could hamper development of important products, or if ignored might allow a dangerous product into the environment. Researchers at the University of Wisconsin – Madison Nanoscale Science and Engineering Center (NSEC) have examined the toxicity of one of the most widely used nanomaterials, titanium dioxide.



Titanium dioxide absorbs energy from sunlight and catalytically produces reactive oxygen species (ROS) from water and oxygen. Using tiny zebrafish embryos as a model vertebrate, NSEC-supported graduate student Ofek Bar-Ilan first showed that TiO_2NPs produce significant toxicity, but only when illuminated. Further examination showed that the fish were being adversely affected by light-induced ROS production when they had been exposed to TiO_2NPs. The group has gone on to examine uptake, organ-specific toxicity, effects of environmental factors such as dissolved organic matter, and the effects of long-term exposure at low concentrations. They are now examining formulations of these nanomaterials that maintain the useful properties of the particles, but do not produce harmful ROS when exposed to light. The group's findings demonstrate that environmental factors need to be considered in determining the potential hazards posed by nanomaterials.

Societal Implications Group

Dominique Brossard, Dietram Scheufele, Michael Xenos

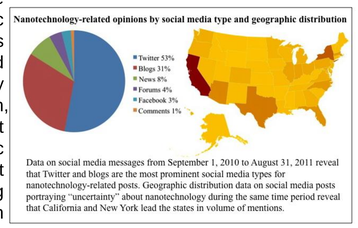
The Societal Implications Group analyzes the potential of the online environment for effective public communication and engagement in nanomaterials related issues.

The Brave New World of (Social) Communication: Exploring Patterns of Opinion (Dissemination) in Online Social Media Environments

Kristin Runge, Dominique Brossard, Dietram Scheufele, Michael Xenos

The growing popularity of social media as a contextual filter and aggregator for media users has become a problem for public opinion research. The sheer volume of blog, Twitter and Facebook posts and their fleeting, un-archived nature makes it a challenge when considering when to sample as well as where to sample. This study uses Crimson Hexagon software to analyze all English-language nanotechnology- related opinions posted on blogs, Facebook, Twitter and other social media websites between September 1, 2010 and August 31, 2011. Results show that posts overwhelmingly expressed certainty and were either optimistic or neutral in attitude. Posts clustered around Twitter and blogs as online channels for nanotechnology social media messages.

After dimensional analysis, posts were mapped by country and state when geographic information was available. State-by-state analysis within the U.S. shows that California, New York, and Texas generated the most nanotechnology posts by volume. The strong trend toward certainty in opinion, optimism and neutrality coupled with the distinct geographic origins of much of the social media traffic for nanotechnology opinion has significant implications for understanding how opinion framing by key influencers determines the direction opinion takes as it is diffused among nanotechnology constituencies.



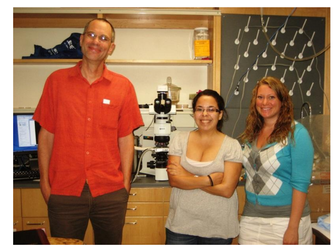
Education / Outreach Group

Andrew Greenberg, John Moore

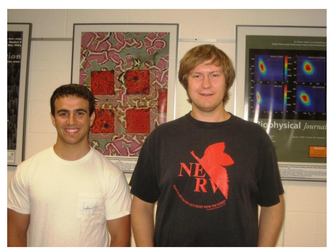
The Educational Outreach Group develops new scaleable teaching and learning programs, methods, and communities, aimed at cultivating a diverse next generation of nanoscientists and engineers.

Education/Diversity: UW REU Students Awarded NSF Graduate Research Fellowships

UW REU Students Jaritza Gomez and Joaquin Resasco were awarded a NSF Graduate Research Fellowship. Jaritza and Joaquin were participants in the 2010 UW REU Nanotechnology program. Joaquin's proposal "*Sorting of Carbon Nanotubes for use in Field Effect Transistors"* will support his research at MIT. Jaritza will conduct her research at UW-Madison.



Jaritza Gomez with Advisor Mark Ediger



Joaquin Resasco with Postdoc Mentor Chris Thode

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We gratefully acknowledge funding from the National Science Foundation, DMR-0832760

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