

SYMPOSIUM X

Frontiers of Materials Research–Innovations to Impact

November 29 - December 2, 2004

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Symposium Support

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* Invited paper

This symposium is the Society's principal vehicle to maintain the interdisciplinary and integrative nature of its mission within the materials community with invited reviews presented over the lunch hour. Leaders in various specialties represented by the topical symposia present reviews designed for materials researchers who are **NOT** specialists in the reviewed field.

SESSION Session X1: Materials Innovations to Impact:
Established and Novel Optics
Chairs: Julia W. P. Hsu and Richard A. Vaia
Monday Afternoon, November 29, 2004
Grand Ballroom (Sheraton)

12:05 PM *X1.1

Optical Fiber: A Materials Innovation. Donald B. Keck, State University of New York, Big Flats, New York.

Starting a new business inside a company is a difficult and lengthy process. The time to move an idea from research to the market place can take a decade or more particularly if the product is radically new. In this talk, the history of the revolutionary optical fiber communications work at Corning will be described. The difficult materials and materials processing problems that were solved to make low-loss optical fibers a reality will be discussed. Even after the low-loss fiber was invented, many other materials innovations were required before optical fiber telecommunications became accepted in the marketplace. Today, over three decades after the original work, more than 800 million kilometers of installed optical fiber forms our communication network backbone, enabling the Internet and providing for our ever more connected nation and world.

12:45 PM *X1.2

Holography – Lighting the Way to the Next Generation of Storage. Lisa Dhar, Sharon Smith and Leslie D. Kramer; Media Development, InPhase Technologies, Longmont, Colorado.

Holographic data storage is a parallel, volumetric optical technology that offers performance capabilities that lie well beyond those possible with traditional storage methods. The powerful combination of high storage densities, high data transfer rates, random access, and removability make holographic storage suitable for wide range of applications – from data and video archiving to content distribution. In this talk, we will describe the key technical breakthroughs that have led to the commercial development of holographic storage systems. We will focus on InPhase Technologies' polymer recording media, from the materials strategy to the manufacturing methods. In addition we will describe InPhase's holographic drive hardware and will demonstrate high performance recording and readout in the integrated media-drive platform.

SESSION Session X2: Materials Innovations to Impact:
Medicine and Sports
Chairs: Shefford P. Baker and Bethanie J. Hills Stadler
Tuesday Afternoon, November 30, 2004
Grand Ballroom (Sheraton)

12:05 PM *X2.1

Innovations in Biomaterials: Achievements and Opportunities. Rebecca Bergman, Medtronic Inc., Fridley, Minnesota.

Materials innovations have been at the heart of many important advances in implantable medical devices. Miniaturization technologies, improved durability and longevity, enhanced biocompatibility, and controlled delivery are several examples where materials innovations have been important in advancing medical products and therapies. Requirements for materials used in the physiological environment are stringent, and include both requirements related to materials properties as well as requirements for safety, quality, and reliability. Looking ahead, materials will undoubtedly continue to be an enabling technology for future innovations in medicine, including novel therapies such as tissue engineering, cell therapy, and gene therapy.

12:45 PM *X2.2

Metallic Liquids and Glasses - Science and Applications. William Johnson, Corporate Office, Liquidmetal Technologies, Lake Forest, California.

The talk will focus on recent developments in the field of bulk metallic glasses and glass forming liquids. We will cover recent progress in developing a fundamental theory of these materials. Other highlights will include new Fe-based "amorphous steels" developed at

Univ. of Virginia and ORNL, toughened metallic glass composites, and high Poisson ratio glasses which exhibit extraordinary ductility. Examples of emerging applications of glassy metals in areas such as sporting goods, electronic casings, and microreplication technology will be given.

SESSION Session X3: Materials Innovations to Impact:
On-Chip Magnetic and Thermal Control
Chairs: Shefford P. Baker and Bethanie J. Hills Stadler
Wednesday Afternoon, December 1, 2004
Grand Ballroom (Sheraton)

12:05 PM *X3.1

Magnetic Spin Devices: 7 Years from Discover to Product. **Where now?** Jim Daughton, NVE Corporation, Eden Prairie, Minnesota.

The discovery of giant magnetoresistance (GMR) in 1988 began a period of intense research into the dependence of electron conduction on their spins in numerous materials and device configurations. Magnetic sensors, including read heads for hard drives, applied GMR materials in products within seven years of the discovery by using GMR "spin valves" and GMR multilayers. New terms, such as synthetic antiferromagnet (SAF), nano-oxide layer (NOL), and CPP (current perpendicular to the plane) devices, were coined to describe discoveries that improved device operations. Initially, magnetic nonvolatile memory using GMR materials were conceived, but memory developments in the past several years have concentrated on magnetic tunnel junctions (MTJs) because of higher signal levels. Magnetoresistive random access memory (MRAM) is nearing production readiness in at least two companies. MRAM has the potential advantages of high density, high speed, nonvolatility, and write cycle durability. Current MRAM research is focused on achieving very high density with reasonably low write currents in order to be competitive with other solid state technologies. Toward these ends, thermally assisted writing and spin momentum transfer writing are being investigated.

12:45 PM *X3.2

From Concept to Commercialization: Multilayer Foils as Rapid Heat Sources for Soldering and Brazing.

Timothy P. Weis, ¹Department of MS&E, Johns Hopkins University, Baltimore, Maryland; ²Reactive NanoTechnologies (RNT), Hunt Valley, Maryland.

Multilayer foils that react exothermically are a new class of nanostructured materials that can be used to solder or braze components together. The multilayer foils range in thickness from 20 to 200 μ m, and they contain hundreds of nanoscale layers that alternate between materials with large heats of mixing, such as Al and Ni. By inserting a free-standing foil between two solder (or braze) layers and two components, heat generated by the reaction of the foil melts the solder and consequently bonds the components. The joining process can be completed in less than one second, in air or in vacuum. The use of reactive foils as a local heat source eliminates the need for torches, furnaces, or lasers, speeds soldering and brazing processes, and dramatically reduces the total heat that is needed. Thus, temperature-sensitive components and metals and ceramics can be joined without thermal damage. This presentation describes the development of reactive foils from concept to commercialization. First, we review the transition from a laboratory observation to that of a new material with clear structure-property relationships, and examples of nanoengineering the temperatures, velocities, heats and ignition of the reactions will be shown. Next, the use of reactive foils as a local heat source for joining is described, showing predictions and measurements of heat transfer during the reactive joining process. The strength and utility of predictive modeling will be demonstrated. Finally, several examples of commercialization will be reviewed, including mounting heat sinks onto CPUs, components onto printed circuit boards and ceramic armor onto tanks. Distinct increases in performance and reliability over conventional bonding methods will be noted, particularly for the case of mounting heat sinks onto Si dies where large decreases in thermal resistance and significant improvements in thermal performance have been demonstrated. The presentation will conclude with a brief description of some of the challenges academic researchers face in transitioning new materials to the market place.

SESSION Session X4: Materials Innovations to Impact:
Meeting Future Energy and Military Needs
Chairs: Julia W. P. Hsu and Richard A. Vaia
Thursday Afternoon, December 2, 2004
Grand Ballroom (Sheraton)

12:05 PM *X4.1

Nanotechnology for Energy Prosperity. Richard E. Smalley,
Carbon Nanotechnology Laboratory, Rice University, Houston, Texas.

Oil was the basis of energy prosperity for the world in the 20th century. Sometime soon, however, worldwide oil production will level out and then start to decline. The historic peaking of world oil production may already be happening now. What will the basis of energy prosperity be for the rest of this 21st century? What could possibly take over from oil? The answer for primary energy generation is likely to be an array of many technologies (clean coal, natural gas, nuclear, solar, wind, biomass) all of which need to be innovated by nanotechnologies. But oil was also our best way of transporting and storing energy. What will take over this role? The best answer is likely to be electricity, transporting terawatts of power over continental distances by high voltage transmission lines, and local storage of this electrical energy in "uninterruptible power supplies" in every house, business, and vehicle. The need and opportunity for enabling nanotechnology innovations in this electrical grid of the future are immense.

12:45 PM *X4.2

Opportunities for Nano-materials in Defense and Homeland Security. Malcolm R. O'Neill, Les Kramer and Sharon Smith;
Lockheed Martin Corporation, Bethesda, Maryland.

The science of nano-materials is of great interest to those of us in the defense and homeland security arenas. As a major defense contractor, we design and manufacture military and space systems for many different platforms and environments. Our current areas of focus include air traffic management, technology services, military space products, precision munitions, information superiority, air and missile defense products, combat aircraft, maritime systems, air mobility, and special mission/reconnaissance aircraft. As we work to enhance our defense and homeland security systems, we are currently using both micro and nanotechnologies and exploring new ways to exploit them. This presentation will focus on the potential for nano-materials to enhance our current and future products and the challenges associated with getting these components into our systems. The following nano-material areas show great promise for our systems: longer range aircraft and longer range, more maneuverable missiles; lighter weight materials for aerospace structures; sensors to identify weapons of mass destruction; energy/ power sources; electronics/photonics for the collection, processing, storage, display and communication of data; and multi-functional materials, coatings, and impermeable textiles. We see a tremendous potential for nanotechnology to revolutionize our products, yet we proceed cautiously as reliability is of paramount importance in our systems. We must be able to accurately model systems that have nano-physical properties different from the larger, heavier products that we deal with today. Other challenges that must be overcome before we can transition a new technology into one of our fielded systems include component cost, packaging, reproducibility, manufacturing, testing, and radiation effects. A large percentage of our components and subsystems are commercial products. These are often not designed to meet military requirements. We must first understand, qualify, modify when necessary, then integrate and test these components. This talk will provide an overview of the opportunities for nano-materials in defense and homeland security and it will address many of the needs and challenges that we can expect in the future.