Manufacturing Science and Technology
Room 103A - Session MS-MoA

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Moderator: Gary Rubloff, Institute for System Research, University of Maryland

1:40pm **MS-MoA1 Metrology of Laser-based Powder Bed Fusion Additive Manufacturing Systems***, **John Slotwinski,*** The Johns Hopkins University Applied Physics Laboratory **INVITED**

Metrology of Laser-based Powder Bed Fusion Additive Manufacturing Systems

John A. Slotwinski, Ph.D.

The Johns Hopkins University Applied Physics Laboratory

Additive Manufacturing (AM, aka 3DPrinting) is a potentially revolutionary manufacturing technology that is changing how both polymer and metal parts can be designed and fabricated. Geometrical complexity, gradient materials, and one-piece assemblies, all of which are difficult or impossible to fabricate with traditional removal processes, are all realizable with additive manufacturing. However, there are several technical challenges that are preventing more widespread adoption of additive manufacturing systems, especially for high-value, mission-critical parts. Chief among these challenges are a lack of full understanding of AM processes, especially for metal AM processes, and the factors influencing the mechanical properties of AM parts. In this talk I will give a brief overview of additive manufacturing processes, describe the technical challenges that are hindering broad adoption of AM parts for critical applications, and describe some recent efforts to measure and better understand both AM processes and AM material properties.

2:20pm **MS-MoA3 Investigation of Superconductive Heavily Doped Boron Diamond for Device Fabrication***, **Delroy Green,** G.L. Harris,* Howard University*; R.D. Vispute,* Bluewave Semiconductor Inc.

Diamond has a wide bandgap of 5.47 eV at room temperature and is the hardest known naturally occurring material with a Knoop hardness of 10,400 kg/mm^2 or 10 on the Mohs scale. Due to the structure of the covalent bonding of its carbon atoms, diamond is extremely strong having each carbon bonded to four neighboring carbon atoms. Although diamond is hard, its toughness, when compared to most engineering materials, is poor. However, because of its hardness, it is an efficient cutting and drilling tool. With the exception of naturally occurring blue diamonds, which are semiconductors, diamond is a good electrical insulator. However, unlike most insulators, diamond has the highest thermal conductivity of 22 W/cm-K among naturally occurring materials. Although diamond is a good electrical insulator, it also shows semiconducting properties when doped with impurities. When diamond is heavily doped with boron the resulting material possess excess electron holes and as such it is classified as a p-type material. If excess boron doping is achieved, then the resulting material is found to behave like a superconductor at very low temperatures. In this superconducting state, the doped diamond conducts electricity.

A series of boron-doped diamond films were grown by hot filament chemical vapor deposition (HFCVD) and tested to determine the optimum technique for doping diamond with boron for superconductivity. The first technique involved the insertion of boron powder (B_2O_3) around the sample holder to dope seeded poly and nano diamond during growth. The second technique involves doping with diborane gas (B_2O_6).

Various processing parameters were optimized for diamond quality, structure, morphology, and doping. A combined analysis of scanning electron microscope, Raman mapping and Hall measurements at various temperatures were conducted to ascertain the superconductive nature of the material. Preliminary results of the boron solid source doping on diamond show a superconductive transition temperature of 2.3 ^{o}Kelvin at a doping concentration of

2.3 x 10^{20} cm^{-3}.

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2:40pm **MS-MoA4 Two-Dimensional Layered Materials For Composites Applications***, **Jorge Catalan,** A. Delgado, A.B. Kaul,* University of Texas at El Paso

Composite materials provide us with an alternative route to combine the characteristic properties from two different materials into one. At the same time, this characteristic of composite materials opens up a new window for different applications such as optoelectronic sensors, strain sensors, capacitive sensor and opto-electro-mechanical sensors. Initially, the isolation of single layered graphene by mechanical exfoliation and nowadays with different methods such ion intercalation, solvent based exfoliation and chemical vapor deposition (CVD) have allowed the utilization of two-dimensional (2D) materials as reinforcement particles into different polymer matrixes for composite materials. This is because 2D materials offer interesting semiconducting properties that might be able to be captured in a polymer-based matrix that provides a ductile medium make them suitable for printable flexible electronic devices and sensors. In this work we have explored graphene, MoS2, and WS2 as possible reinforcement material in different polymers matrixes. The first type of composite consisted of a poly-methyl-methacrylate (PMMA) matrix with different type of fillers (graphene, MoS2 and WS2). The second type of composite materials that we studied consists of a poly-isoprene matrix (natural rubber band) and graphene, MoS2, and WS2 as reinforcement material. We have conducted strain testing on the structures we have fabricated to make strain-dependent electrical and optical properties. The PMMA/filler material composite was optically and electrically characterized under different strains with the help of different fixtures with different radius of curvature. On the other hand, the poly-isoprene composites were characterized with the help of a self-made type of clamp that allows us to strain the rubber band like composite to different degrees and measure the electrical characteristics of the compound. The opto-electro-mechanical characterization was developed with the scope of utilizing these composite materials as strain or flexible sensors for health monitoring or non-destructive evaluation.

4:00pm **MS-MoA8 AIM Photonics – Manufacturing Challenges for Photonic Integrated Circuits***, **Michael Liehr,*** SUNY Polytechnic Institute **INVITED**

Abstract: The recently established American Institute for Manufacturing Photonics (AIM Photonics) is a manufacturing consortium headquartered in NY, with funding from the US Department of Defense, New York State, California and Massachusetts, and industrial partners to advance the state of the art in the design, manufacture, testing, assembly, and packaging of integrated photonic devices . Dr. Michael Liehr, CEO of AIM Photonics, will describe the technical goals, operational framework, near-term milestones, and opportunities for the broader photonics community.

The scope of AIM Photonics will span several industry segments, with the most prominent and near term commercial segment of Datacom applications, to analog/RF, array and sensor applications that are expected to mature at a later time. Photonic Integrated Circuits (PIC) technology enables optical systems to be miniaturized and fabricated on semiconductor chips. Just as electronic integrated circuits revolutionized electronics by miniaturizing transistor circuitry, PICs integrate lasers and other optical devices to route and process information with reduced size and power. PICs can also scale in complexity to do things that would not be possible using conventional optical design approaches. By putting these components on a single platform, PICs have the potential to advance technology in ways never before possible.

Targeted markets include:

Ultra-high-speed transmission of signals for the internet and telecommunications

New high-performance information-processing systems and computing

Compact biomedical sensor applications enabling dramatic medical advances in diagnostics and treatment

Multi-sensor applications including urban navigation, free space optical communications, and quantum information sciences

Other military applications, including electronic warfare, analog RF sensing, communications, and chemical/biological detection

4:40pm **MS-MoA10 Development of III-Nitrides for Energy Harvesting Applications***, B. Kucukgok, N. Lu,* Purdue University*;* ***IanT. Ferguson,*** Missouri University of Science and Technology

III-Nitride wide-bandgap semiconductors have recently enabled state-of-the-art technologies for energy harvesting applications, such as photovoltaics and thermoelectrics. III-Nitride materials and devices have provided tremendous advantages due to their distinguished features, including tunable bandgap, superior electrical properties, high-temperature stability, enhanced chemical stability, and mechanical strength. Furthermore, InGaN with indium compositions up to 30% (2.5 eV band gap) have been developed for photovoltaic applications by controlling defects and phase separation. Additionally, InGaN solar cell design consists of 2.9 eV InGaN p-n junction sandwiched between p- and n-GaN layers results in internal quantum efficiencies as high as 50%; while devices utilizing a novel n-GaN strained window-layer enhanced the open circuit voltage. These results establish the potential of III-Nitrides and related materials in ultra-high efficiency photovoltaics. Moreover, thermoelectrics, conversion of waste thermal energy into electrical energy, have seen pioneering developments over the past 20 years. A figure of merit ZT, used to measure the efficiency of the thermoelectric materials. Various approaches have been taken to increase the efficiency of thermoelectric materials, such as electron quantum confinement and phonon scattering to increase the power factor and decrease the lattice thermal conductivity, respectively. The objectives of this study are to highlight the use of III-Nitrides in high efficient photovoltaic and thermoelectric energy harvesting applications. Some recent measurements of the thermoelectric properties–the Seebeck coefficient, the electrical conductivity and the power factor–of GaN and InGaN thin films will also be reported.

Author Index

Bold page numbers indicate presenter