Wednesday Morning, December 10, 2014

Nanomaterials
Room: Hau - Session NM-WeM

Nano Composites
Moderator: David Williams, The University of Auckland, New Zealand

8:20am **NM-WeM2 Microwave Absorption Properties of Core Double-Shell FeNi@/BN@BaTiO$_3$ Nanocapsules**, ***Shi G.M***, Shenyang University of Technology, China

Abstract

Recently, with the rapid advancement of wireless communication, the microwave absorbing materials are becoming increasingly important for applications in some special fields such as silent rooms, radar systems and military applications. Among the candidates for EM wave absorbers, magnetic nanocapsules, i.e. magnetic nanoparticles coated with an insulator shell including graphite, oxidation etc., are now becoming a study focus of researchers. The reason is that this type of EM wave absorbers not only possess a high saturation magnetization and Snoek's limit at high frequencies, but also decrease eddy current phenomenon induced by electromagnetic wave.

The determining key factor of microwave absorption performance of the absorbents is EM impedance matching of the absorbents. Multilayer structures are a good way to increase EM impedance matching. However, the relative permittivity due to the interface polarization in the heterogeneous composites is rarely focused on. BaTiO$_3$ with excellent dielectric/ferroelectric properties has been studied for its EM wave absorption properties, and FeNi nanoparticles with large saturation magnetization are prominent magnetic microwave absorbents. Hence, in this study, core double-shell FeNi@/BN@BaTiO$_3$ nanocapsules were synthesized by a two-step [app:addword:synthesis] method, consisting of an arc- evaporating a FeNi-B amorphous alloy target in a mixture atmosphere of Ar and N$_2$ and a subsequent chemical liquid deposition process . Microwave absorption properties of core double-shell FeNi@BN@BaTiO$_3$ nanocapsules were investigated in the 1–18 GHz frequency range. High resolution transmission electron microscopy studies the core double-shell type nanocomposite with FeNi nanoparticles as the core, while BN and BaTiO3 are the inside and the outside shells, respectively. Enhanced relative permittivity made the core double-shell FeNi @BN @BaTiO$_3$ nanocapsules with better electromagnetic impedance matching than that of a FeNi@BN and BaTiO3 mixture. Reflection loss (RL) values of FeNi@BN@BaTiO$_3$ paraffin composite are far greater than those of the FeNi@BN –paraffin composite at the absorbent thickness from 1.1 to 6 mm . An optimal Reflection lossof -40.3 dB was reached at 10.9 GHz with 1.5 mm thickness, and the broadest absorption bandwidth of 5.9 GHz (*RL*<-10dB) is from 8.7 to 14.6GHz frequency range. The microwave absorptive mechanisms of BN@BaTiO$_3$ coated FeNi nanocapsule absorbent were discussed.

8:40am **NM-WeM3 Nanocomposite Coatings – Playing with Nanostructures to Achieve New Properties**, ***Joerg Patscheider***, Empa, Switzerland **INVITED**

Thin film technologies allow the preparation of materials that are compositionally modulated down to the nanometer scale. When the grain size of crystalline materials approaches the ten nanometer range, the properties known from their large-scale counterparts often change substantially. Such changes affect electronic and optical properties as well as the mechanical behavior of nanoscaled thin films. Examples include hard materials with built-in functionalities such as coloration, designed frictional properties through a variety of mechanisms as well as hardness-enhancement in wear-resistant coatings. Nanocomposite coatings, which consist of nanocrystalline nitrides or carbides can provide combinations of advantageous properties such as enhanced hardness and low friction for the case of TiC/a-C:H, high hardness and optical transparency in Al-Si-N thin films or designed thermal conductivity with oxynitride coatings for wear protection on cutting tools. Various examples of nanostructured thin film systems will be presented and the underlying principles for the successful operation of such thin film materials will be discussed.

9:20am **NM-WeM5 High Thermal Conductivity with Electrically Insulating Ceramic/polymer and Ceramic/Ceramic Nanocomposite Films Using Ceramic Nanosheets**, *C.H. Kim, S. Nahm,* Korea University, Republic of Korea, ***HyoTae Kim***, Korea Institue of Ceramic Engineering and Technology, Republic of Korea

High thermal conductivity films with electrically insulating properties have a great potential for the effective heat transfer as substrate and thermal interface materials in high density and high power electronic packages. There have been lots of studies to achieve high thermal conductivity composites using high thermal conductivity fillers such alumina, aluminum nitride, boron nitride, CNT and grapheme, recently. Among them, boron nitride(BN) and aluminum nitride(AlN) ceramics are promising candidate for high thermal conductivity with electrically insulating filler materials. This work presents an enhance heat transfer properties of ceramic/polymer and ceramic/ceramic nanocomposite films using BN/AlN nanosheets(nanoflake) and polymer resins. BN nanosheet was prepared by a chemical expoliation using organic media and subsequent ultrasonic treatment. High thermal conductivity over 5W/mK in transverse and 10W/mK in in-plane direction of cast films were achieved for BN nanosheet/polymer nanocomposites that were prepared under 250°C. Also, thermal conductivity over 5W/mK were achieved for BN/AlN nanosheets/glass ceramic composites which can be sintered under 900°C. Further improvement of thermal conductivity up to 15W/mK was achieved by applying high thermal conductivity polymers and adequate alignment of nano size ceramic sheets and high density packing through multimodal powders and two stage film forming process including first cast, resin infiltration and pressured-roll cast at elevated temperatures.

9:40am **NM-WeM6 Magnetoluminescent Nanoparticles For Detection And Treatment Of Cancer By Thermal Ablation**, ***Nuyeli Izaguirre***, Centro de Investigación Científica y de Educación Superior de Ensenada, Mexico, *A. Hirata*, Centro de Nanociencias y Nanotecnología, Universidad Nacional Autónoma de México, Mexico

In recent years has increased the interest for developing multifunctional materials which can be used for diagnosis and therapies for major diseases such as cancer. The purpose of this work is the synthesis and characterization of luminescent/magnetic nanoparticles (LMNPs) made of magnetite (Fe$_3$O$_4$) and their simultaneous combination with europium doped lanthanum oxide (La$_2$O$_3$:Eu), terbium doped lanthanum oxide (La$_2$O$_3$:Tb) or thulium doped lanthanum oxide (La$_2$O$_3$:Tm) for possible applications as contrast and thermal ablation agents in cancer treatment.

The method used to obtain the LMNPs is spray pyrolysis due it allows the synthesis of nanoparticles with narrow size distribution, adjustable size, high crystallinity and good stoichiometry. Luminescent nanoparticles were prepared with different concentration of dopant material and were post annealed at different temperatures in order to find the best luminescent response. Once obtained the luminescent materials with the highest luminescence, the synthesis of magnetoluminescent materials was followed. This second step was done for different concentration of luminescent and magnetic nanomaterials in order to obtain the best multifunctional properties material. The determination of the best material was made by characterizing the nanoparticles with different techniques such as spectrophotometry, X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and measurement of magnetic properties using a vibrating-sample magnetometer (VSM) and a magnetic induction device.

Partial support from CONACyT (Grant 100555) and DGAPA-UNAM (Grant IN-109913) and technical work provided by E. Aparicio, F. Ruíz and I. Gradilla is gratefully acknowledged.

10:40am **NM-WeM9 Nanoparticles-Reinforced Aluminum Matrix Composite Materials Fabricated by Powder Technology**, ***SeungjinKim Kim***, *K. Kim, J. Cho,* Pukyong National University, Republic of Korea, *S. Cho,* Korea Institute of Materials Science, Republic of Korea, *M. Leparoux,* Empa, Switzerland, *H. Kwon,* Pukyong National University, Republic of Korea

Nanosized silicon carbide (nSiC) particles were used as a solid mixing agent in order to homogeneously well dispersion of the carbon nanotubes (CNT) in the aluminum (Al) powders by a high energy ball milling process. The CNT-nSiC-Al composite powder was prepared depending on different milling times of 10, 30, 60, 180, and 360 min. The nSiC particles were well infiltrated into the CNT agglomerations and induced physical separation of the CNTs. Another expected advantage of nanoparticle mixing agents is that no necessary to remove the mixing agent after bulk fabrication, because they are also can be offered fine-particle-strengthening effect. The powder particle size and morphology showed differently depending on the process times. A lot of flaky morphology of the Al particles was observed until 60 min milled one. However, relatively spherical shapes of the Al powder particles were observed over 180 min milled conditions. It is estimated that morphology of the Al powder particles which is highly affected to final materials properties can be controlled by controlling milling times. The composite powders have been sintered by spark plasma sintering (SPS) process. The SPSed composite materials were characterized based on microstructure, hardness, crystallite, and defect rate of the CNT in the composites. The SPSed flaky-composite powders showed lower relative density (around 98%) than the SPSed spherical-composite powder which was fully densified. However, the Vickers hardness of the SPSed spherical-composite powders were showed almost three times higher values than the SPSed flaky-composite powders. It means that the morphology of powder particles is significantly affected to the hardness of composite materials. However, we believe that the nanoparticle mixing agent could be used for CNT-reinforced composite materials system.

11:20am **NM-WeM11 Surface Modification with Polyhedral Oligomeric Silsesquioxanes Silanols**, ***Luis Cabrales**, F. Valencia, K. Calderon, I. Hinojosa*, California State University Bakersfield

Hydrophobicity, water repellency, is a desirable surface property for materials in many industries. Water repellent surfaces are used to prevent deleterious effects of water such as; corrosion and degradation, on various materials. There are several methods which can be used to modify the properties of surfaces. Some of these techniques include sol-gel method, plasma, chemical vapor deposition, atomic layer deposition, and also traditional wet chemistry methods. Some novel materials for surface modification are Polyhedral oligomeric silsesquioxanes (POSS) silanols. These materials possess some of the surface modification characteristics of other silicon-based materials.In this project, Polyhedral Oligomeric Silsesquioxanes (POSS) were used to treat hydrophilic materials such as cotton and glass. Two POSS silanols, TriSilanolIsooctyl POSS and TrisilanolPhenyl POSS, were deposited by immersion methods on glass and polymeric surfaces. Several concentrations and curing temperatures were evaluated. Contact angle measurements of water and other liquids were used to calculate the surface properties and wettability. Dynamic capture mode was used to calculate the hysteresis of advancing and receding contact angles. The hysteresis provided information regarding the wettability properties of the obtained surfaces. Statistical Analysis was performed on the contact angle data collected from the glass, cotton, and PVA samples. The analysis of the PVA films coated with TrisilanolIsooctyl POSS demonstrated an effect of the curing temperature in the water repellency. Whereas the PVA coating with the TrisilanolPhenyl POSS had a lower variability in the contact angle as the curing temperature was increased. The cotton samples coated with POSS where compared with contact angles measured at 10 seconds and 60 seconds after placing the droplet. The results for 0.1% TrisilanolPhenyl POSS cotton samples proved that only water repellency is achieved at higher curing temperatures. The results of 4% TrisilanolPhenyl POSS cotton samples showed a higher repellency even at lower curing temperatures at 10 seconds. The results of the contact angles at 60 seconds demonstrated that as the curing temperature is increased, the coating prevents the absorption of water. The results demonstrated that POSS can impart hydrophobic properties to these materials even at low concentrations. The unique properties of POSS silanols for surface modification are also discussed.

11:40am **NM-WeM12 Application of Ultrananocrystalline Diamond/Hydrogenated Amorphous Carbon Composite Films to Photodiodes**, ***Tsuyoshi Yoshitake**, Y. Katamune, T. Hanada, S. Takeichi*, Kyushu University, Japan, *S. Ohmagari*, National Institute of Advanced Industrial Science and Technology

Ultrananocrystalline diamond (UNCD)/hydrogenated amorphous carbon (a-C:H) composite (UNCD/a-C:H) films are aggregates consisting of ultrananocrystalline diamond (UNCD) grains of less than 10 nm in diameter and an a-C:H matrix [1]. In our previous study, we have realized the film growth without the pretreatment of substrates using diamond powder by pulsed laser deposition (PLD) and coaxial arc plasma deposition (CAPD), and experimentally proved the formation of p-type and n-type conductions accompanied by enhanced electrical conductivities by the doping of boron and nitrogen, respectively [2,3].

In this work, heterojunctions diodes comprising B-doped UNCD/a-C:H films and n-type Si substrates were fabricated by PLD and CAPD and they were evaluated as photodetectors. The B-doped UNCD/a-C:H showed obvious photoconduction in the UV and visible ranges. Heterojunction diodes exhibited a typical rectifying action. Photocurrent was evidently observed, and the external quantum efficiency was estimated to be more than 70% for UV monochromatic light under negative biases.

[1] T. Yoshitake et al., Jpn. J. Appl. Phys. 48, 020222 (2009).

[2] S. Ohmagari et al., Jpn. J. Appl. Phys. 50, 035101 (2011).

[3] S. Al-Riyami et al., Appl. Phys. Express, 3, 115102 (2010).

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