ASME Materials Division Fall News 2011

The Chair's Message

Mohammed Zikry- Division Chair

I am honored to be writing to you as the chair of the Material Division (MD). With about 3,000 members, the MD is the one the largest of the six divisions constituting the Basic Engineering Group of the ASME. It is also one of the fastest growing divisions in the Engineering Group. I am honored to have worked on the Executive Committee with Vikas Prakash (Vice Chair, Case Western Reserve University), Julie Chen (Honors and Awards (University of Massachusetts, Lowell), Karl Jacob (Georgia Institute of Technology, Program), Junlan Wang(University of Washington, Secretary/Treasurer), and George Voyiadjis(Louisiana State University, Member at Large). I want to thank them all for their wonderful support and friendship as we worked together to push forward the research, educational, and service missions of the Division.

We have had a highly active year with Divisional highlights that include:

• The largest number ever for presentations and symposia with over 600 presentations and twenty-five symposia

• The launch of two new technical committees, **Nano Medicine** (Professor Gang Bao, Georgia Institute of Technology, Chair), and **Nano Energy** (Martin Dunn, Chair, University of Colorado, Xie Chen, Columbia University, Vice Chair)

• The support of student travel awards to attend and present at the **NSF Poster Competition**, which is also jointly sponsored by the Materials Division and organized by Emmanuelle Reynaud from the University of Massachusetts Lowell.

• The Sponsoring of Poster awards with NSF on the **Micro/Nano Technology Forum**, which has been organized by Daniel Attinger (Iowa State), Tony Jun Huang (Pennslyvania State University), and Vikas Prakash (Case Western Reserve University)

• A leading role with **The ASME NanoEngineering Council** to foster collaboration among ASME's technical divisions for technical interaction collaboration among nanotechnology researchers. Vikas Prakash, the MD Vice- Chair is the current Council Chair, and Julie Chen, the MD Honors and Awards Chair is the current Council Secretary.

The Division is also honored to announce that Professor Subrah Suresh (Massachusetts institute of Technology, Director of the National Science Foundation) will receive the 2011 **Nadai Award**, Professor Julia Greer (California institute of Technology) will receive the 2011 **Sia Nemat**

Nasser Award, and Samantha Daly (The University of Michigan) will receive the 2011 **Orr Early Career Award**. All three awardees will give lectures at the Denver IMECE, and these lectures will be followed by the Division reception. One of the things that make me most proud of having served on the MD Executive Committee for the past five years and chairing the division during the past year is that the MD is home to so many outstanding individuals, who commit their time and effort to furthering the mission of the Materials Division. This includes current and past members of the Executive Committee and our Technical Committee Chairs and members. The Division owes a special debt of gratitude to Jacinta McComie of ASME for her tireless support, effort, and energy to ensure that we are able to accomplish Division objectives. She has been an invaluable asset and friend.

-M. A. Zikry

ASME Journal of Engineering Materials and Technology

Hussein M. Zbib

The ASME Journal of Engineering Materials and Technology (JEMT) continues to attract top-quality, peer-reviewed research papers from all over the world. During the period July 2010 through July 2011, four issues were published including two special issues. One was entitled Recent Advances on Composites and Heterogeneous Materials, Guest Editor Professor Valeria La Saponara (UC Davis) and Professor Assimina A. Pelegri (Rutgers University), and one entitled Multiphysics Approaches for the Behavior of Polymer-Based Materials, Guest Editor Professor Said Ahzi (University of Strasbourg, France). Special thanks to the Guest Editors for their hard work. Also last year the following three new Associated Editors have been elected to serve on the Board of Editors: Dr. Irene Beyerlein (Los Alamos National lab), Professor Marwan Khraisheh (Masdar Institute, UAE), and Professor Ashraf Bastawros (Iowa State University); their service to JEMT is greatly appreciated.

Also, and on behalf of the MD, many thanks are extended to Professors Guany Analas, Somnath Ghosh and Yanyao Yiang for their valued services as Associated Editors (2007-2011). Finally, congratulation to the recipients of the 2010 Orr Best Paper Award: Fabien Bogard, Philippe Lestriez, and Ying-Qiao Guo -Université de Reims Champagne Ardenne, France

Authors are strongly encouraged to submit their papers to JEMT. The journal covers a broad spectrum of issues regarding experimental, computational and theoretical studies of mechanical properties of materials, as well as mechanics of materials issues in metals, polymers, ceramics, composites, biomaterials, and nanostructured materials. Important topics include, multiscale characterization, modeling and experiments; high-temperature creep, fatigue and fracture; elastic -plastic behavior; environmental effects on material response, constitutive relations, materials processing, and microstructure mechanical property relationships. http://journaltool.asme.org/Content/JournalDescriptions.cfm?journalId=8&Journal=MATS

Editor: Hussein M. Zbib

2011 Nadai Award Winner

S. Suresh Biography

Dr. Subra Suresh is the 13th director of the National Science Foundation (NSF). Suresh leads the only federal agency charged with advancing all fields of fundamental science and engineering research and education. Prior to his confirmation as NSF director, Suresh served as Dean of the Engineering School and Vannevar Bush Professor of Engineering at the Massachusetts Institute of Technology (MIT). He joined MIT's faculty ranks in 1993 as the R.P. Simmons Professor of Materials Science and Engineering. During his more than 30 years as a practicing engineer, he held joint faculty positions in four departments at MIT as well as appointments at the University of California at Berkeley, Lawrence Berkeley National Laboratory and Brown University.

A mechanical engineer interested in materials science and biology, Suresh pioneered research to understand the mechanical properties of materials. His most recent research tackled the biomechanics of red blood cells under the influence of diseases such as malaria. In 2006, *Technology Review* magazine selected Suresh's work on nanobiomechanics as one of the top 10 emerging technologies that "will have a significant impact on business, medicine or culture." Holding true to his personal ideals, Suresh successfully leveraged his renowned research and leadership positions in academia to increase the number of women and minority engineers. He personally mentored more than 100 engineers and scientists in his research group. As department head and dean of engineering, he also led a successful campaign to increase the number of women among MIT's engineering faculty ranks.

He has received numerous awards including the Padma Shri Award (2011) from the President of India, Indian Science Congress General President's Award (2011), Society of Engineering Science Eringen Medal (2008), European Materials Medal (2007) and the Acta Materialia Gold Medal (2006). He holds honorary doctorate degrees from Sweden's Royal Institute of Technology and Spain's Polytechnic University of Madrid. He has been elected a fellow or honorary fellow of all the major materials societies in the United States and India, including the American Society of Materials International, Materials Research Society, American Society of Mechanical Engineers, American Ceramic Society, the Indian Institute of Metals and the Materials Research Society of India.

Suresh has authored more than 230 research articles in international journals and is a co-inventor in more than 18 U.S. and international patent applications. He is author or co-author of several books that are widely used in materials science and engineering, including *Fatigue of Materials* and *Thin Film Materials*. He has consulted with more than 20 international corporations and research laboratories and served as a member of several international advisory panels and non-profit groups. Suresh has been elected to the U.S. National Academy of Engineering, American Academy of Arts and Sciences, Spanish Royal Academy of Sciences, German National Academy of Sciences, Academy of Sciences of the Developing World, Indian National Academy of Engineering and Indian Academy of Sciences. He earned his bachelor's degree from the Indian Institute of Technology in Madras in 1977; his master's from Iowa State University in 1979; and his doctorate from MIT in 1981.

2011 Nemat-Nasser Award

Julia R. Greer- Ph.D., Stanford University, 2005; M.S., Stanford University, 2000; B.S., Massachusetts Institute of Technology, 1997

Useful properties of structural materials are generally governed by their bulk microstructure. For centuries, the improvements in structural materials relied heavily on processing, which in turn, dictated the resulting microstructure and properties. With the current rapid shift towards interdisciplinary materials science, significant improvements have been enabled by the development of microstructure-property relationships specifically by introducing a new design parameter, *size.* As we enter a revolutionary era in materials science, where specific material properties are attained through not only material but also architecture control of its constituents, often with micron- or sub-micron dimensions, it is imperative to develop a thorough understanding of material mechanical deformation properties at the appropriate scale.

Julia Greer's research focuses on the problems of unraveling the physical origins of size-dependent mechanical properties in nano-scale solids, where the presence of surfaces causes the emergence of unexpected deformation mechanisms in response to mechanical deformation. It has been shown, for example, that in single crystals strengths increase in a power law fashion with sample size reduction once micron scale is reached, and therefore can no longer be inferred from the bulk response or from literature. They are thought to arise from the distinct defect behavior that emerges as a result of reducing material dimensions to the nano-scale and manifest themselves by causing unusual mechanical properties. While these studies provide a powerful foundation for the fundamental deformation processes operating in these materials at small scales, they are a far reach from representing real materials used in structural applications, whose microstructure is often complex, containing boundaries and interfaces. In fact, both homogeneous (grain boundaries, twin boundaries, etc.) and heterogeneous (i.e. phase boundaries, precipitate-matrix boundaries, and even free surface) interfaces in size-limited features are crucial elements in the structural reliability of most modern materials. Establishing the link between the observed mechanical properties and microstructural evolution remains a grand challenge, and one of the unique aspects of Greer's research is the ability to establish a more quantified, predictive relationship between the two.

Julia Greer's key research accomplishments lie in the development of innovative experimental approaches that enable *assessing* mechanical properties of nano-sized solids and *explaining* them through evolved *microstructure.* One approach involves fabrication of nano-scale samples with different initial microstructures (i.e. containing boundaries, interfaces, interphases, dislocations, etc.) ranging from below 50 nm to ~ 1 micron by using ion- and electron-beam assisted patterning, lithography and electroplating. In order to test their strengths in uniaxial tension and compression Greer built a unique nano-mechanical deformation instrument with simultaneous electrical measurement capability, SEMentor, comprised of Scanning Electron Microscope (SEM) and nanoindenter. She has utilized this *in-situ* technique to address four specific classes of problems:

1. Size effects in plasticity of crystalline metals. Experimental results on uniaxial deformation of single crystals present us with an intriguing mystery: in a striking deviation from classical mechanics, we and others have demonstrated a "smaller is stronger" phenomenon in face-centered cubic (fcc), body-centered cubic (bcc), and hexagonal close-packed single crystals manifested by the significant (~50x) increase in strength as material size is reduced to below 100 nm. Further, very recently her group performed nano- mechanical tests on smallest-ever fcc nano-pillars and showed the emergence of strain rate sensitivity in fcc nano-crystals (not present at bulk scale), distinctly illustrating the transition in plasticity mechanism to dislocation nucleation control. Greer's group remains at the forefront of studying small-scale crystalline plasticity, having produced more than 40 publications on the topic and having recently written an invited review article on the topic in *Progress in Materials Science*. Expanding her studies towards boundary- containing materials, she discovered that nanocrystalline metals exhibit the opposite trend: "smaller is weaker" while bi-crystalline metals remain unaffected, i.e. exhibit an identical size effect to their single crystalline counterparts.

2. Mechanical behavior of nano-scale amorphous glasses. Beyond crystalline metals, Greer has made significant contributions in studying small-scale response of metallic glasses (amorphous metallic alloys). A common understanding of metallic glasses is their failure via catastrophic shear band formation. Greer's group discovered that these materials attained superior strength and plastic deformability of ~ 25% (unprecedented at that point) when reduced to ~100 nm. Further, her group showed that to utilize this size-induced ductility towards useful applications, thin layers of metallic glasses can be combined with either crystalline metals or polymers into nanolaminates, thereby retaining the high strength and non-catastrophic deformation.

3. Energy absorption in vertically aligned carbon nanotube (VACNT) bundles. Carbon nanotube forests have shown promise for energy dissipation and cushioning applications. In order to elucidate deformation mechanisms operating in VACNT forests, Greer's group performed *in-situ* uniaxial micro- compression experiments on cylindrical VACNT bundles with diameters of 50 μm and heights of ~65 μm (individual carbon nanotube diameters are 20nm-50nm). Greer's group demonstrated that their deformation was accommodated by sequential nucleation of local buckles followed by their lateral propagation across the bundle, gradually collapsing a horizontal slice of the entire structure in a periodic fashion. She discovered that buckles occurred successively, from bottom to top. Using this complicated structural response as both motivation and confirmation, Greer's group proposed and developed a dynamic, finite-deformation finite element model based on a viscoplastic solid. Previous modeling efforts for CNTs were limited to fully recoverable one-dimensional load-deflection responses. This model was the first to propose a constitutive law – relating stress and strain – for the material, thereby allowing for capture of both the load-deflection response and the structural response, i.e., the evolution of surface undulations and lack of recoverability.

4. Mechanical-electrical coupling in graphene. Greer's group has recently embarked on exploring the effect of mechanical strain on the electronic structure of graphene, which has a zero band gap under normal circumstances. The suspended geometry of graphene sheets and nano-ribbons lends itself well to the investigation of mechanical-electronic coupling in the SEMentor. Together with computational simulations, Greer's group recently showed that inducing tensile strain on the order of 4% is unlikely to result in band gap opening and does not appear to affect the energy dispersion in graphene.

2011 Orr Early Career Award

Samantha H. Daly- Ph.D., Mechanical Engineering, California Institute of Technology, 2007
M.S., Mechanical Engineering, California Institute of Technology, 2002
B.E., Mechanical Engineering modified with Mathematics, Dartmouth College, 2001

Samantha Daly has shown excellence in research early in her career through her pioneering work in the area of fracture and fatigue of engineering materials. She has used her innovative approaches to investigate the fundamental mechanisms underlying phase transformations in active materials, the superplastic effect in nanostructured metallic alloys, high cycle fatigue in metals, and local damage accumulation and fracture in high temperature composites. Shape memory alloys undergo stress induced phase transformation and are prone to localizing deformation and a quantitative understanding of the deformation in these alloys had been lacking. Daly performed the first quantitative measurements of local strains and visualization of the discrete nature of deformation in the shape memory alloy nitinol using

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the digital image correlation (DIC) technique. She investigated the fracture mechanics and mechanisms and was the first to provide reliable measurements of fracture toughness of thin sheets of this novel material. She also performed the first small scale transformation analysis of a crack in nitinol and has laid the foundations of fracture mechanics for shape memory alloys. Daly combined 3D digital image correlation (DIC) and infrared (IR) imaging to simultaneously map local strain fields temperature variations Using this combined methodology, she has for the first time directly quantified the complex local interactions between released/absorbed latent heat and the local development of strain under fatigue. These investigations have resulted in the discovery of new phenomena in fatigue: she discovered evidence of a strong strain memory in the manner in which shape memory alloys accommodate a stress-induced martensite phase. In the area of fracture, she found unexpected mechanisms behind the local damage accumulation that drives brittle failure in high temperature composites. Her research findings have important implications for both the fundamental understanding of materials as well as their use in practical applications such as cardiac stents and other biomedical applicaitions. Daly has also recently developed a new methodology that combines quantitative microstructural mapping with ultrasonic fatigue testing at 20 kHz. This approach enables her to capture a wealth of detailed information on deformation mechanisms in the very high cycle fatigue regime (>109 cycles). Using this approach, she obtains full-field, quantitative information on the local microstructural changes that are known to drive high cycle fatigue, and can obtain this data at orders of magnitude faster than conventional fatigue testing.More recently, Daly combined scanning electron microscopy with a deformation tracking technique known as Digital Image Correlation (DIC). This approach, termed SEM-DIC, provides for highly accurate, full-field maps of the strains accommodated by and around microstructural features, such as grains or composite fibers. Daly has addressed the key challenges to making this technique successful, including the correction of errors introduced by stress relaxation, and the creation of a technique to extract local deformations such as the relative motion of one grain sliding with respect to another grain, which are important in quantifying the nucleation of cracks in fracture and fatigue at the micro-scale.

News from the Technical Committees (continued)

Materials Processing Committee

Ram V. Mohan

Committee Chair

The materials processing technical committee has actively and successfully pursued organization of events and symposia for the exchange of technical information and findings related to various aspects of materials processing including new directions in nanomaterial processing, multi-scale, hierarchical materials, bio-materials, etc., that are of current research, technical and applications of interest to the community and ASME at large. The materials processing technical committee sponsored/co-sponsored three successful symposia in key emerging areas at the IMECE 2010 in Vancouver, Canada.

These are in the areas of “Innovations in Processing, Characterization, and Applications of Bioengineered Materials”, “Processing, Characterization, Modeling and Applications of Hybrid and Multi-Scale Material Systems”, and “Damage Mechanics of Engineering and Engineered Materials”. All these symposia were well organized, attended and received by the IMECE 2010 participants at large.

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The materials processing technical committee plans to continue organizing future symposia and forums, workshops and other technical exchange activities at IMECE and other conferences for 2011 and beyond, in several emerging materials processing technology areas of interest and relevance to the field, as well as in the emerging areas of nanomanufacturing, nanoengineered materials for energy applications, hierarchical, multi-scale, and bio-materials. The materials processing technical committee is sponsoring symposia in the following areas at IMECE 2011 in Denver, CO.

- Nanoengineered Materials for Energy Applications, cosponsored by the Nanoengineering for Energy Systems Steering Committee of the ASME Nanotechnology institute.
- Innovations in Processing, Characterization, and Applications of Bioengineered Materials
- Machining of new materials
- Scalable Methods for Processing of Nano-Engineered Materials, Structures, and Devices, cosponsored by NEMS Division
- Processing and Characterization of Bio-inspired and Bio-mimetic Materials
- Mechanical Property Characterization and Modeling of Novel Materials at Different Size Scales

Members of the materials processing technical committee have been active in various activities at ASME. This includes serving in the awards committees for materials division; steering committee on nanoengineering for energy systems of the ASME nanotechnology institute. Future plans to organize technical podcasts, webinars; assessment based courses, workshop series, web based technical modules, etc., via working closely with ASME organization are envisioned in the future. Such potentials will be discussed during IMECE 2011 technical committee meeting.In order further strengthen the material processing technical activities and to bring focused synergism in the technical area of material processing, a motion was proposed by the Materials Processing and Manufacturing Technical Committee (current chair: Dr. Xin Wu) initially during IMECE 2009 in Orlando to form a MD/AMD Joint Materials Processing

Technical Committee. Subsequently, MD Materials processing technical committee was approached with this possibility in early January 2011 by Prof. Cherukuri (Vice Chair: AMD Materials Processing and Manufacturing Technical Committee). A need for a proposal on the logistics was mentioned by Dr. Xin Wu for such a joint committee, but has not received further interest from AMD. There is a potential for AMD technical committee chair and vice chair to discuss this possibility during IMECE 2011. If such a joint MD/AMD technical committee could be formed, it would be similar to the AMD/MD Joint Constitutive Equation Technical Committee.

ASME Materials Division materials processing technical committee (MD-MPTC) meetings are held every year during IMECE. The materials processing committee is committed to supporting symposia and forum for technical exchanges in emerging materials processing technology areas including emerging areas of nano, nanoengineered materials, bio-materials, hierarchical and multi-scale materials that require interdisciplinary focus and interactions, and encourage members of materials and engineering community and other ASME divisions to contact the technical committee chair with proposals for symposia and other technical activities. Please contact the current chair (Prof. Ram Mohan, rvmohan@ncat.edu) if you would like to participate in ongoing activities or initiate new activities in the technical areas of relevance to materials processing, innovative material developments, processing, characterization, modeling, materials processing and applications for energy, nanotechnology and infrastructure applications, interdisciplinary technology areas, as well as industrial practices.

News from the Technical Committees (continued)

Polymer Technical Committee

Frank Fisher

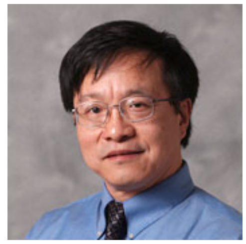
Committee Chair

The Polymers Technical Committee actively seeks to provide different forums for members of the Committee and others interested in polymeric materials to network and exchange ideas and research findings with colleagues in industry, academia, and various research laboratories. This past summer the committee organized a *Symposium on Polymer Nanocomposites: Structure and Function* at the 2011 ASME Applied Mechanics and Materials Conference (McMAT2011) held in Chicago, IL. The symposium was comprised of four sessions and 21 contributed talks ranging in areas from molecular/atomistic modeling approaches to structure-property relationships to processing and functional properties to experimental characterization techniques. The Committee in particular thanks Professor Pawel Keblinksi of RPI for providing a timely keynote presentation related to the modeling of thermal transport in carbon nanofiber composites to start the symposium.

At the 2011 IMECE Conference in Denver the Polymers Technical Committee is organizing or co-organizing talks to be presented in two topics. Highlighting the talks presented in Topic 4-3, *Polymers and Composites for Energy Generation, Packaging, and Storage*, will be a keynote address from Cheryl Kennedy of the National Renewable Energy Laboratory (NREL) on "The Performance and Durability of Candidate Polymeric Advanced Solar Mirrors for Concentrating Solar Power". The second area is Topic 12-16, *Structure-Property Relationships of Polymers and Composites*, where Dr. Eyal Zussman from Technion will contribute an invited talk in the area of electrospun polymer fibers.

Lastly, the Committee would like to thank the past Chair of the Committee, Professor Meisha Shofner of the School of Materials Science and Engineering at Georgia Tech, for her tremendous contributions to the Committee. If you are interested in participating in the activities of the Polymers Technical Committee or have suggestions for future programming, please contact Frank Fisher, Department of Mechanical Engineering, Stevens Institute of Technology (Frank.Fisher@stevens.edu) or Shing-Chung (Josh) Wong, Department of Mechanical Engineering, University of Akron (swong@uakron.edu).

Nanomedicine Technical Committee



Gang Bao

Committee Chair

Nanomaterials and nanostructures with at least one dimension between 1-100 nm have received growing interest over the past few decades as a result of their unique and fascinating properties, and applications superior to their bulk counterparts. There is a large number of powerful opportunities that may be realized through synthesis, functionalization and application of nanostructures. Although initially driven by microelectronics applications, in recent years, nanotechnology research has shifted to nanomedicine as well, which enables highly sensitive disease diagnosis and highly specific medical interventions at the nanoscale for curing disease and repairing damaged tissues. Nanotechnology has the potential to revolutionize the science and practice of modern medicine, including pediatrics. Due to the nano-size induced unique physical/chemical properties, nanoengineering capabilities and tunable functions such as specific targeting of diseased cells and organs, nanomaterials (including nanoparticles and nanostructures) and nanodevices provide unprecedented opportunities for achieving more precise alteration and control of biological processes, and drastic improvements in disease detection, therapy, and prevention. For example, compared with existing technologies, nanoparticle-based molecular imaging probes can have much higher sensitivity in disease diagnosis; nanocarriers can have targeted drug/gene delivery with significantly enhanced efficacy and reduced side effects; and nanomachines can precisely modify genes, thereby treating genetic disorders and other diseases with much higher efficacy (Fig. 1). These and other potential applications of nanotechnology have already broken new ground in medicine, and hold the promise to dramatically alter healthcare delivery.

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News from the Technical Committees (continued)

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As a new field in science, engineering and medicine, nanomedicine provides wonderful opportunities for researchers in materials science and engineering. As part of the National Nanotechnology Initiative (http://www.nano.gov/), over the last 7 years or so, nanomedicine has received strong support by funding agencies including NIH and NSF, as demonstrated by the NIH Nanomedicine Development Centers (NDC) program, the NIH/NHLBI Programs of Excellence in Nanotechnology (PEN), NIH/NCI Centers of Cancer Nanotechnology Excellence program (CCNE), and the NSF Nanosystems Engineering ERC program. It is expected that nanomedicine will receive sustained support from the federal funding agencies as well as private sectors.

The establishment of the new Technical Committee on Nanomedicine provides a platform to stimulate a broader interest in nanomedicine among members of the Materials Division of ASME, to promote their active participation in nanomedicine research, education and innovation, and help develop a closer interaction with the other organizations in nanomedicine and respond to funding opportunities. This TC will organize symposia on nanomedicine research at future ASME conferences, including the IMECE and Applied Mechanics and Materials Summer Conference. We also plan to organize a Workshop on Nanomedicine, jointly sponsored by MD and AMD. Your support and help in developing the new field of nanomedicine would be very much appreciated.

Gang Bao
Chair of Technical Committee on Nanomedicine

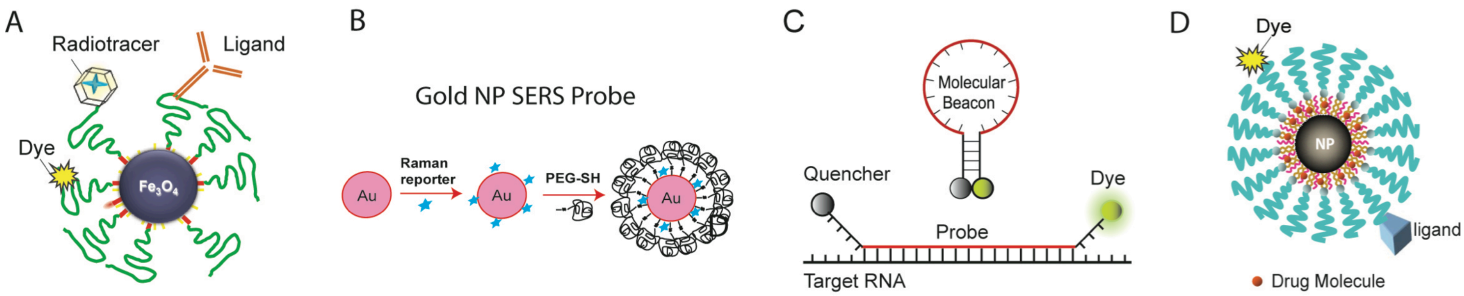

Figure 1: Examples of nanomedicine tools, including: (A) superparamagnetic iron oxide nanoparticle probes for MRI and combined MR/PET imaging, (B) gold nanoparticle-based surface enhanced Raman spectroscopy (SERS) probes for *in vitro* disease diagnosis, (C) molecular beacons for RNA detection in living cells and clinical samples, (D) nanocarriers for *in vivo* drug/gene delivery in disease treatment.

Materials Division Executive Committee 2010-2011

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Materials Division Website

The website for materials division is located at:
http://divisions.asme.org/Materials/
Members are encouraged to contact the web editor if they have pertinent information for posting.

Materials Division Technical Committees 2010-2011

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