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Announcement

2011 Acta Materialia, Inc. Gold Medal Award

Jagdish Narayan

The winner of the 2011 Acta Materialia Inc Gold Medal Award is Professor Jagdish (Jay) Narayan who currently holds the John C.C. Fan family Distinguished Chair Professorship in the Department of Materials Science and Engineering at North Carolina State University. He also has the appointment of Distinguished Visiting Scientist at Oak Ridge National Laboratory. After graduating with distinction from India's top institution (IIT Kanpur) in 1969, Professor Narayan continued his studies at the University of California, Berkeley, and obtained his MS (1970) and PhD (1971) degrees in a record time of two years. Based on his MS and PhD theses, he published over a dozen leading papers related to in-situ studies of defects and diffusion modeling in leading archival journals, initiating a long lasting research career, mostly in the area of functional materials. To date Dr. Narayan has published over 500 journal papers and numerous contributions to conference proceedings. He has also received 35 patents. His research publications have been quoted in over 11,000 citations with h-index of over 51.

After graduation, Dr. Narayan worked (1971–1972) as Research Metallurgist at Lawrence Berkeley National Laboratory, before joining Oak Ridge National Laboratory in 1972 as Member of Research Staff. At ORNL, he rose to the level of Senior Scientist and Group Leader of Thin Films and Electron Microscopy Programs, before joining in 1983 North Carolina State University as Senior Professor and Director of Microelectronics Center of North Carolina. He was appointed Distinguished University Professor in 1991, and Endowed Fan family Distinguished Chair Professorship in 2001. During 1990–1992, Professor Narayan also served as Director of Division of Materials Research, National Science Foundation. There he initiated a successful Program on Advanced Materials and Processing, for which he received the NSF Distinguished Service Award. Professor Narayan's research covers all of the critical elements of advanced materials: synthesis and processing; nanoscale characterization; structure-property correlations and modeling.

His pioneering experiments at Berkeley provided first direct evidence for the presence of anion-cation vacancy pairs (Schottky defect) and anion-cation interstitial pairs (New defect) in ionic crystals such as magnesium oxide. He showed that these defects diffuse as pairs and obtained activation energies for bulk diffusion and pipe diffusion along dislocations and grain boundaries. He also discovered new

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a{100} dislocations as result of condensation of these vacancy type defects. At ORNL he used this fundamental understanding to form colloids (nanoclusters) of metals in MgO, and invented novel metal-ceramic (nano) composites with improved mechanical, electrical and thermal properties.

Professor Narayan's expertise in defects and diffusion was well suited for the next phase of his career at ORNL on ion implantation, solid phase epitaxy, rapid thermal annealing, and formation of supersaturated semiconductor alloys. He established atomic structure of displacement cascades and developed an amorphization model for semiconductors based upon his careful experiments which led to the determination of critical damage energy for amorphization (12eV/atom for silicon). His work on solid-phase-epitaxy kinetics led to the well-known crystallization model and the discovery of supersaturated semiconductor alloys with solubility limits exceeding as much as 500 over the equilibrium values, a critical step in ion implantation doping for ultra-shallow p-n junctions in current and future devices.

Narayan and his coworkers at ORNL pioneered pulsed laser annealing methods, useful for removing ion implantation damage and creating "defect-free" supersaturated semiconductor alloys. These seminal experiments on interfacial instability also have led to theoretical models to establish melting as the mechanism of laser annealing. Narayan also invented laser induced diffusion to form highly efficient ultra-shallow p–n junctions and low-cost laser-diffused solar cells. Subsequent research in laser (transient thermal) processing resulted in the discovery of flame annealing and rapid thermal processing, which constitutes the backbone of current device fabrication.

Narayan's critical understanding of laser-solid interactions led to nonequilibrium pulsed laser evaporation at higher laser energies, and deposition of thin films. His group at NCSU (along with Bell Labs) published first seminal paper on pulsed laser deposition (PLD) of thin films of high-T_c superconductors in 1987. Since then, PLD technique has become one of the most popular techniques for thin film deposition along with MOCVD and MBE. The PLD is proving to be an elegant nonequilibrium technique, lending itself to higher quality films of multicomponent systems at lower thermal budgets with fewer processing steps.

In other research areas, Dr. Narayan discovered domain matching epitaxy, a new paradigm for thin film epitaxy across the misfit scale, which is based upon matching of integral multiples of lattice planes across the film-substrate interface. This is a crucial step in the fabrication of GaN based light emitting diodes on sapphire and silicon substrates where lattice misfit can range from 14% to 20%. Narayan also invented novel "Nano Pocket" LEDs where carriers are quantum confined by introducing a thickness variation to control the bandgap of GaInN/GaN quantum wells. The thickness variation is introduced during thin film growth as a result of misfit strain between GaInN and GaN layers. Using this paradigm of epitaxy across the misfit scale, it is possible to integrate functionality of new materials on the silicon chip and create smart devices for sensing, manipulation and rapid response. In the area of new materials, Dr. Narayan discovered 1-2-4 ($Y_1Ba_2Cu_4O_8$) superconductors T_c 80–100K and 1-2-4 and 1-2-3 ($Y_1Ba_2Cu_4O_{7-\delta}$) composites with enhanced flux-pinning. He discovered ZnMgO and ZnCdO alloys for LEDs and doped ZnO based materials as transparent conductors, and pioneered epitaxial growth of diamond thin films on Si(100) and Cu(100) substrates. The pulse laser method for synthesis and processing of continuous diamond thin films on nondiamond substrates, such as Cu(100), makes it possible to create hydrogen-free diamondlike carbon films.

During various stages of his research career, Dr. Narayan developed atomic-resolution electron microscopy techniques to study the atomic structure of defects (dislocations) and interfaces, which are based upon a three-step interactive procedure: calculation simulation and comparison with experimental results.

Professor Narayan's outstanding research contributions have earned him many awards and recognitions. He is an elected Fellow of MRS (inaugural Class), TMS, APS, AAAS, ASM, and a Fellow of the National Academy of Sciences in India. His awards include the US-DOE Outstanding Research Award, Three IR-100 Awards, Honorary Member MRS-I, ASM Gold Medal, and Edward DeMille Campbell Lecture and Prize, IIT/K Distinguished Alumnus Award. In 2005 at the Annual TMS Meeting in San Francisco a symposium was held in Dr. Narayan's honor.

The Acta Materialia Gold Medal is awarded annually by the Board of Governors of Acta Materialia, Inc. with partial financial support from Elsevier, the publisher of Acta journals. Nominees are solicited each year from the Governors, the Cooperating Societies and Sponsoring Societies of Acta Materialia, Inc. based on demonstrated ability and leadership in materials research. A distinguished panel of international judges makes the determination of the winner. The Award consists of the gold medal, donated by the publisher, Elsevier, an inscribed certificate, and a check for a sum of money that constitutes the Board's contribution to the award winner.

There will be an International Conference on Advances in Nanostructured Materials and Applications (designated as The 2011 Acta Materialia Gold Medal symposium honoring Professor Narayan), sponsored by ASM International and TMS at the Materials Science 20, 2011, Columbus, Ohio. The Acta Materialia Gold Medal will be presented at the ASM Awards Ceremony on October 18, 2011. The Materials Research Society will hold an Invited Symposium on Frontiers of Thin Film Epitaxy and Nanostructured Materials, in Professor Narayan's Gold Medal honor, at the 2011 MRS Spring Meeting in San Francisco, April 25–29, 2011.