**Introduction:**

Nasr Ghoniem is internationally renowned as a materials scientist for his seminal scientific contributions. His research has included a range of materials science and materials physics problems, exemplified by a unique understanding of the role of fundamental materials science in advancing technological innovation. He conducted and led research in the areas of damage and failure of materials, defect mechanics and physics, material degradation in severe environments, plasma and laser processing, self-organization and instability phenomena, and radiation interaction with materials. Nasr’s publication record includes over 350 publications (280 refereed journal articles), with over 5000 citations (Google Scholar). He edited eight books on applied plasma science, multiscale modeling of materials, plasticity & fracture, and nano- and micro-mechanics, and is the co-author of a two-volume book (1100 pages) published by Oxford Press (2008): Nasr M. Ghoniem and Daniel Walgraef, Instabilities and Self-Organization in Materials, Volume I: Fundamentals of Nanoscience, Volume II: Applications in Materials Design and Nanotechnology. The first volume lays the mathematical and computational foundations of multiscale modeling methods in materials science. The second volume provides the reader with many applications of self-organization phenomena in areas as diverse as thin films, crystal growth, radiation effects, surface roughening, plasticity, fracture, plasma and laser processing, and nano-particle self-organization. Nasr is well-known for his contributions that have shaped the development of material science in recent decades: (1) his extensive work on the theory of microstructure evolution in irradiated materials; especially helium transport, and helium-vacancy cluster formation, (2) his invention of a class of ferritic/ martensitic steels that have the property of “low-activation,” with vastly reduced radioactivity levels than prior steels used in nuclear applications, (3) his conceptualization of the method of “Dislocation Dynamics,” as a viable materials science computer simulation tool for investigations of metal plasticity at multi-scales, (4) his tireless efforts to work with leaders in the materials science community for the establishment of the field of multiscale modeling, which has spurred many recent research activities and captured the imagination of many scientists and funding agencies by breaking barriers between traditional disciplines, and (5) his research on self-organization and pattern formation phenomena in materials far from equilibrium.

**Ghoniem’s Key Scientific Achievements:**

During his Ph.D. research at the University of Wisconsin, Nasr developed theoretical models for the dynamics of point defects and void swelling in structural materials under pulsed irradiation. His theoretical research on the effects of radiation pulsing on materials has defined many of the characteristics of microstructure evolution and several macroscopic properties, and his findings were confirmed by subsequent experiments. Prior to Nasr’s work, the rate theory of void swelling (and microstructure evolution in irradiated materials) has systematically divided the problem into a nucleation phase and a growth phase. However, extension of classical nucleation theory to the clustering of point defects produced by irradiation was not successful prior to Nasr’s work. Building on his Ph.D. thesis work on the formulation of a dynamic rate theory for pulsed systems (e.g. NM Ghoniem, GL Kulcinski, “A critical assessment of the effects of pulsed irradiation on the microstructure, swelling, and creep of materials,” *Nucl. Technol./Fusion*, **2(2),** 165-198, 1982, and NM Ghoniem, “The early stages of void and interstitial loop evolution in pulsed fusion reactors,” *JNM*, **89**, 359-371,1980), Nasr developed a comprehensive framework for the rate theory of microstructure evolution that included both nucleation and growth simultaneously, and resulted in direct correlations between theory and experiments (NM Ghoniem, DD Cho, “The Simultaneous Clustering of Point Defects during Irradiation,” *Physica Status Solidi* (a) 54 (1), 171-178, 1979, EP Simonen, NM Ghoniem, NH Packan, “Pulsed flux effects on radiation damage,” *JNM,* **122 (1–3)**, 391–401, 1984). He pioneered the development of theoretical and computational methods to thoroughly represent components of the microstructure in irradiated materials (e.g. voids, bubbles and interstitial clusters/ loops) with hierarchies of rate equations. Nasr’s contributions in this area include the following:

1. Development of the Fokker-Planck stochastic theory of atomic clustering, with several applications to microstructure evolution, diffusion of helium in irradiated materials, and has generalized the method to study the growth of thin films (e.g. NM Ghoniem, S Sharafat, “A numerical solution to the Fokker-Planck equation describing the evolution of the interstitial loop microstructure during irradiation, *JNM*, **92 (1)**, 121-135, 1980, NM Ghoniem, “Stochastic theory of diffusional planar-atomic clustering and its application to dislocation loops,” *Physical Review B* **39 (16)**, 11810, 1989, and H Huang, NM Ghoniem, “Formulation of a moment method for multidimensional Fokker-Planck equations,” *Physical Review E* **51 (6)**, 5251, 1995).
2. Development of the rate theory of helium transport and clustering in irradiated materials, with numerous applications to grain boundary fracture and swelling of irradiated materials, and in investigations of thermal and irradiation creep (e.g. NM Ghoniem, S Sharafat, JM Williams, and LK Mansur, “Theory of helium transport and clustering in materials under irradiation,” JNM, **117**, 96-105, 1982, NM Ghoniem, ML Takata, “A rate theory of swelling induced by helium and displacement damage in fusion reactor structural materials,” *JNM* **105** (2-3), 276-292, 1982, and NM Ghoniem, JN Alhajji, D Kaletta, “The effect of helium clustering on its transport to grain boundaries, *JNM* **136 (2)**, 192-206, 1985).

With his former students, Nasr developed some of the earliest works in atomistic simulations of radiation interaction with materials. He developed Monte Carlo (MC) and Molecular Dynamics (MD) simulations of radiation interaction with materials. The computer program that he developed with his former student Phillip Chou (Transport of Ions in Polyatomic Materials, TRIPOS) preceded the commercially popular code TRIM, routinely used nowadays for ion implantation studies (P Chou, NM Ghoniem, “Precipitate dissolution by high energy collision cascades,” *JNM,* [**117**](http://www.sciencedirect.com/science/journal/00223115/117/supp/C), 55–63,1983). His work on atomistic simulation of radiation interaction with materials has two salient achievements:

1. Ion implantation and preferential sputtering in heterogeneous materials (PS Chou, NM Ghoniem, “Applications of the Monte Carlo code TRIPOS to surface and bulk ion transport problems,” *Nuclear Instruments and Methods in Physics Research*, **28 (2)**, 175-184, 1987, and SP Chou, NM Ghoniem, “Molecular dynamics of collision cascades with composite pair--many-body potentials,” *Physical Review, B*, **43 (4)**, 2490-2495, 1991);
2. Effects of cosmic radiation on microelectronic materials (MOS microchips). The problem of “Single-Event Upset,” where single, highly energetic cosmic particles, caused loss of guidance and control in early satellites and other spacecraft. His work with his former student, Roger Martin, and industrial collaborators, has paved the way to develop mitigation strategies for this problem (e.g. RC Martin, NM Ghoniem “Monte Carlo Simulation of Coupled Ion‐Electron Transport in Semiconductors,” *Physica Status Solidi (a)* **104 (2)**, 743-754, 1987, Martin, R. C., Ghoniem, N. M., Song, Y., Cable, J. S., “The Size Effect of Ion Charge Tracks on Single Event Multiple-Bit Upset,” *Nuclear Science, IEEE Transactions*, **34 (6)**, 1305- 1309, 1987. Vu, K.N., Cable, J.S., Witteles, A.A., Kolasinski, W.A., Koga, R., Elder, J.H.; Osborn, J.V., Martin, R.C., and Ghoniem, N.M., “Experimental and analytical investigation of single event, multiple bit upsets in poly-silicon load, 64 K×1 NMOS SRAMs,” *Nuclear Science, IEEE Transactions*, **35 (6)**, 1673-1677, 1988).

Early in his career, and because of his keen understanding of the connection between fundamental materials science research and technological innovations, Nasr was the first to recognize the importance of environmentally friendly structural materials, where he ventured into the experimental development of low-activation steels. He holds the first world patent on the development of low activation ferritic/martensitic steels for (U.S. Patent No. 4,622,067, November 11, 1986 (with D. S. Gelles and R. W. Powell). These early experimental efforts by Nasr have paved the way for worldwide research programs to develop structural steel alloys for fission and fusion energy applications that are environmentally-friendly, yet of superior high-temperature performance. His interest in the applied side of materials science has led to a widely cited co-authored publication (with Zinkle, 120 citations) that has helped guide the selection and development of high-temperature structural materials in nuclear energy applications (SJ Zinkle, NM Ghoniem, “Operating temperature windows for fusion reactor structural materials,” *Fusion Engineering and Design* **51**, 55-71, 2000).

Nasr recognized the importance of silicon carbide as a high-temperature material that has vast potential in the electronics and nuclear industries. He mentored several Ph.D. students and guided them to work on fundamental aspects of defects, and on swelling and fracture processes in SiC and SiC/SiC composites. The two students whom he mentored in this area are currently chaired professor at UConn (Huang) and full professor at Purdue (El Azab). The basic determination of point defect formation and migration energies in SiC was laid out by Nasr and his group (H Huang, NM Ghoniem, JK Wong, M Baskes, “Molecular dynamics determination of defect energetics in beta-SiC using three representative empirical potentials,” *Modell. & Sim. in Mat. Sci. & Eng.* **3**, 615, 1995 – 85 citations, H Huang, N Ghoniem, “A swelling model for stoichiometric SiC at temperatures below 1000 OC under neutron irradiation,” *JNM*, **250 (2-3)**, 192-199, 1997; H Hanchen, N Ghoniem, “Neutron displacement damage cross sections for SiC, *JNM*, **199 (3)**, 221-230, 1993, and El-Azab, A.; Ghoniem, M., ”Viscoelastic analysis of mismatch stresses in ceramic matrix composites under high-temperature neutron irradiation,” *Mech. of Mat*., **20** (4), 291-303, 1995.)

Nasr established a very productive experimental and modeling research program on plasma processing of *materials* at UCLA in the 1990’s. He collaborated with some of the leading Japanese scientists on establishing a successful series of international conferences on Applied Plasma Science. Together with Kobayashi (Osaka University), they established and maintained a bi-annual conference on applications of plasmas in materials science and produced several conference proceeding (Akira Kobayashi and Nasr M. Ghoniem, co-editors, “Advances in Applied Plasma Science, Vol. I” Proc. of the 1st Int. Symp. on Appl. Plasma Science, 22-26 Sept. 1997, UCLA, Los Angeles, CA., USA, 198 pages, and Vol. II” Proc. of the 2nd Int. Symp. on Appl. Plasma Science, 20-24 Sept. 1999, Osaka Sun Palace, Osaka, Japan, 453 pages). Since he and Kobayashi started the series at UCLA in 1997, the bi-annual event is continuing the contribution to the science of materials processed by plasmas and ions. Nasr and his former students have contributed significantly to the specific area of plasma spray of micro-structured high-temperature coatings in a series of experimental and theoretical papers (e.g. S Sharafat, A Kobayashi, Y Chen, NM Ghoniem, “Plasma spraying of micro-composite thermal barrier coatings,” *Vacuum* **65 (3-4)**, 415-425, 2002; A Kobayashi, S Sharafat, NM Ghoniem, “Formation of tungsten coatings by gas tunnel type plasma spraying,” *Surface and Coatings Technology* **200 (14)**, 4630-4635, 2000; MD Demetriou, NM Ghoniem, A S Lavine, “Kinetic modeling of phase selection during non-equilibrium solidification of a tungsten-carbon system,”

*Acta Materialia*, **50 (6)**, 1421-1432, 2002.)

An important characteristic of Nasr’s research is his ability to transfer knowledge from neighboring fields and thus enrich the science of materials. He had a significant collaboration with leading theoreticians in Europe and South America to establish methodologies of non-linear dynamics in the materials science field. The success of the mathematical methods of non-linear dynamics in understanding pattern selection, stability and bifurcations in fluid and chemical systems led Nasr to establish a decades-long collaboration with Daniel Walgraef. Together, they tackled several self-organization and pattern formation phenomena in non-equilibrium materials (e.g. D Walgraef, J Lauzeral, NM Ghoniem, “Theory and numerical simulations of defect ordering in irradiated materials,” *Physical Review B,* **53 (22)**, 14782,1996, J Lauzeral, D Walgraef, NM Ghoniem, “Rose Deformation Patterns in Thin Films Irradiated by Focused Laser Beams,” *Phy. Rev. lett.* **79 (14)**, 2706-2709, 1997; D Walgraef, NM Ghoniem, “Nonlinear dynamics of self-organized microstructure under irradiation,” *Physical Review B* **52 (6)**, 3951, 1995). Their collaboration resulted in the systematic exposition of the subject of self-organization of materials in a rigorous framework that was published in a two-volume book by Oxford Press in 2008.

Around 1987-1988, Nasr pioneered the development of a ground-breaking computational method, known now as “Dislocation Dynamics,” for the simulation of the collective dynamics of three-dimensional line defects (dislocations) that are the fundamental carriers of plastic flow in materials (N.M. Ghoniem, R.J. Amodeo, “Computer Simulation of Dislocation Pattern Formation,” in *Non-Linear Phenomena in Materials Science I*, L. Kubin and G. Martin, Eds., 377-388, 1988, RJ Amodeo and NM Ghoniem, “Dislocation dynamics. I: A proposed methodology for deformation micromechanics,” *Physical Review B* **41 (10)**, 6958, 1990, “Dislocation dynamics. II: Applications to the formation of persistent slip bands, planar arrays, and dislocation cells,” *Physical Review B* **41 (10)**, 6968, 1990. His research has led to worldwide (and continuing) efforts to establish a physical theory of plasticity and fracture of materials, with significant implications in the design of advanced materials. Prior to this work, the mechanical properties were derived from the behavior of single dislocations in empirically conceptualized models. His early fundamental contributions in this area have led to the emergence of an elegant and rigorous computational method for simulation of plastic flow and fracture, as well as understanding of basic dislocation properties (e.g. NM Ghoniem, SH Tong, LZ Sun, “Parametric dislocation dynamics: a thermodynamics-based approach to investigations of mesoscopic plastic deformation,” *Physical Review B,* **61 (2)**, 913, 2000; NM Ghoniem, LZ Sun, “Fast-sum method for the elastic field of three-dimensional dislocation ensembles,” *Physical review B* **60 (1)**, 128, 1999.” As a result of advances in material characterization techniques, and the miniaturization of sample geometry, direct experimental comparisons between computer simulations and experiment have lent great credence to the fidelity of the dislocation dynamics method as a reliable tool to investigate the mechanical behavior and to rationalize experimental observations on a physical basis (e.g. JA El-Awady, M Wen, NM Ghoniem, “The role of the weakest-link mechanism in controlling the plasticity of micropillars,” *J. of the Mech. & Phys. Sol.*, **57 (1)**, 32-50, 2009.)

**Materials Science Contributions and Service:**

Nasr Ghoniem has made numerous and important, long-term contributions to the Materials Research Society. He has been an active member and participant in MRS activities for two decades. Through his participation in MRS activities, he worked with a number of scientists to establish the field of “Multiscale Modeling of Materials.” The first step taken was through an MRS Symposium (Bulatov, T. Diaz de la Rubia, R. Phillips, E. Kaxiras, and N. M. Ghoniem, Co-editors, “Multiscale Modeling of Materials,” *Proc. of the 1998 MRS Soc. Symp*., 538, 1999, 591 pages). A highly cited general reference for this effort was published by Phil Mag: NM Ghoniem, EP Busso, N Kioussis, H Huang, “Multiscale modelling of nanomechanics and micromechanics: an overview,” *Philosophical Magazine*, **83 (31-34)**, 3475-3528, 2003. In addition, he organized several successful MRS symposia (Co-Organizer, International Symposium on ”Multi-Scale Modeling of Materials”, MRS Fall Meeting, Boston, November 1998, Co-Organizer, International Symposium on ”Multi-Scale Modeling of Materials”, International Union of Materials Research Societies (IUMRS), Beijing, China June 1999; Co-Organizer, MRS Symposium on the Limits of Strength in Theory and Practice, MRS Fall Meeting, Boston, November 2000).

**Other Professional Service**

Nasr is a member of ANS, TMS, MRS, APS, ASME and the American Academy of Mechanics. Nasr Ghoniem has made important contributions to a number of other professional societies and activities. He is on the editorial boards of several scientific journals (JNM, CMES, IJMD, JCTN, & guest editor for MRS, Vacuum, Phil Mag., and JCAD) and is an associate editor of Defect & Diffusion Forum (Scitec Publishers), and Solid State Phenomena (Scitec Publishers). In addition, he organized several successful conferences and symposia on radiation effects, plasticity and fracture, and multiscale modeling (he was the general chair of the Second International Multiscale Materials Modeling Conference in Los Angeles, 2004). He is the Editor of the Proc. of the 2nd Int. Conf. on Multiscale Materials Modeling (MMM-2), Los Angeles, CA., October 2004, 484 pages.

**Honors and Recognition**

Nasr is a Fellow of the Materials Research Society (2014), and the American Academy of Mechanics (2010). He was given the “Lifetime Achievement Award of the Multi-scale Modeling International Advisory Board (2008); an International Symposium on Defect Mechanics was held in Honor of his 60th Birthday during the 4th Inter. Conf. on Multiscale Modeling, Tallahasse, Fl (2008), followed by a publication of a special issue in Phil Mag in commemoration (Symposium on Defects in Materials (Tallahassee, Fla.), *Phil Mag / Special issue*, 27/28; (2010)). Nasr was awarded the “Outstanding Achievement Award of the Materials Science Division of ANS (2007); he is a Fellow of the American Society of Mechanical Engineers (ASME) (2006); he was the General Chair: 2nd Int. Conf. on Multiscale Materials Modeling (MMM-2) (2004); he was awarded the UCLA Faculty/ Staff Partnership Award (2003). Nasr held the “Royal Society of London Visiting Professorship” in Hong Kong (2000), and a Research Fellowship of the Japan Society for the Promotion of Science (JSPS) (1999). He was also awarded the “Outstanding Achievement Award” of the American Nuclear Society - Fusion Energy Division (1998). He is a Fellow of the American Nuclear Society (ANS) (1994), and has been selected for the “Outstanding Young Man of America” Award (1978).

**Mentor and Educator**

His long career at UCLA as an educator resulted in 35 Ph.D.’s. Eight of his former students ended up as professors, while the others hold leading positions in National Labs or the industry. In addition, he mentored 40 Master’s students, and supervised over 25 post doctoral and professional staff members from many areas of the world. In addition, seven of his former post-doctoral students hold professorial positions as well, making a total of 15 professors from his group alone. One of his former students is currently the chair of the Nuclear Engineering Department at the University of Wisconsin, Madison (Jake Blanchard), and another holds an endowed chair professorship at the University of Connecticut (Hanchen Huang). Several other former students hold leadership positions in National Laboratories (Roger Martin, ORNL, and Philip Chou, LLNL). Nasr’s educational and mentoring impact is felt in the US and around the world in the fields of radiation interaction with materials, and the mechanics and physics of defects. His former students have charted new directions in materials science and mechanics emanating from his dedicated mentoring and guidance.

**Summary**

In summary, Nasr Ghoniem is an internationally recognized scholar and scientific leader in the materials science and physics communities, as well as a dedicated member of the Materials Research Society. He plays a prominent and active national role in science and technology directions on challenging national and international issues associated with mechanics and materials science. His career is characterized by original research, many outstanding scientific accomplishments, an exceptional publication record, national scientific leadership, and a highly successful role in mentoring and educating the next generations of materials scientists.