

Candidate's Statement

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Upon joining ASU in January 2000, I set the goal for myself of achieving excellence in research, teaching, service, and proper balance among the three activities. In particular, this has involved: (i) developing an innovative, diverse, and exciting extramurally-funded research program in the area of mechanical behavior of materials at multi-length scales; (ii) teaching and training undergraduate and graduate students in an effective fashion, whether in the classroom or in the laboratory, while also developing novel teaching tools and techniques; and (iii) effective service to the department, college, university, and materials community. I sincerely believe that I have been very much on track in achieving my goals. What follows is a brief narrative of the highlights of my activities, subdivided into the three major areas.

Research

Most engineering materials encounter some type of mechanical loading during their service lifetime. Thus, an understanding of the mechanical behavior of materials is extremely important. The broad objective of my group's work is to develop a fundamental understanding of the mechanical behavior of materials at various length scales. To enable us to work toward this goal, I have obtained approximately \$1.4 million in single-investigator research grants while at ASU (Research grants-84%, Gifts-14%, and equipment and material donations-2%), including the National Science Foundation Early Career Award and the Office of Naval Research Young Investigator Award. I have also established the interdisciplinary Mechanical Behavior of Materials Facility, which is open to industry and faculty and students at ASU. The facility is equipped with state-of-the-art servohydraulic mechanical testing equipment, furnaces, and specimen preparation facilities. A partial list of industrial participants in the Facility includes: Intel, 3M, Indium, Hoeganaes, Ford, GM, DaimlerChrysler, and MTS Systems. Some highlights and impact of our research are listed below:

- In collaboration with industrial partners, we are developing a novel, low-cost, near net-shape sinter-forging technique for processing lightweight metal matrix composites (MMCs). Materials processed by this technique exhibit extremely promising tensile and fatigue properties. Innovative techniques for quantifying microstructural defects in MMCs, e.g., particle clusters, have been developed, and a link between these defects and fatigue resistance is being established. We also have the exciting new capability of microscopic observation of fatigue crack growth behavior in these materials *in situ*.
- We are developing an understanding of the mechanical behavior of new environmentally-friendly alternatives to Pb-Sn solder. In particular we have demonstrated that solder cooling rate has a significant impact on microstructure evolution and creep properties of Pb-free solders and solder/Cu substrate joints. Furthermore, our research has shown that the behavior of the actual solder ball, used in the electronic package, is markedly different from that of the bulk solder.
- Using a novel and sophisticated microforce testing system, we have demonstrated that ceramic fibers are susceptible to cyclic fatigue, despite the lack of plasticity at room temperature in these materials. The system is also being used to evaluate the mechanical integrity of human and animal tissue (in collaboration with the Department of Bioengineering at ASU).
- Near-net shape sintered ferrous alloys are increasingly being used in several structural applications. While these materials can be processed to near net shape, they frequently have a significant amount of residual porosity. Our work has highlighted the important effects of porosity and alloying additions (in changing the microstructure of the alloy) on the fatigue behavior of these alloys. This knowledge is directly being used to develop newer, more fatigue resistant materials by the industry.

Our research at ASU has resulted in 23 total papers published or in press (9 additional papers have been submitted or are in preparation). 51 presentations have been made, including several invited seminars and invited talks at international meetings. Most of the papers and presentations included graduate and undergraduate student collaborators as co-authors. Finally, a \$5 million proposal to the National Science Foundation toward creating an International Materials Institute (IMI) on Multi-component Materials at Multi-Length Scales has been submitted and is currently under review.

Teaching

I firmly believe that teaching and research activities should be balanced and, whenever possible, they should be complementary activities. In this regard, my philosophy is to have students learn the fundamentals in the classroom, and then have them apply these concepts by exposing them to cutting edge research in the laboratory. The combination of

education and research is a particularly effective tool for enhancing undergraduate learning, skills, and interest in the field. Some of the highlights of my teaching are:

- Teaching evaluation scores have been very good, showing consistent improvement. Quantitative self-assessment by students (where they rate their knowledge in a specific subject area covered in the course) indicates a significant increase in knowledge from the beginning to the end of the semester. I have also developed a new course on Composite Materials, which received excellent feedback from the students.
- I have developed several new tools to enhance classroom instruction, such as Object Oriented Finite (OOF) Element Analysis technique in undergraduate laboratories for simulating the behavior of material microstructures. I've also incorporated new modernized lab experiments into my courses. Another novel aspect of my teaching is the incorporation of "special topics" in the courses that I teach, to illustrate course concepts in modern day applications. Some examples of special topics include: *Materials Issues in the World Trade Center Attack*, *Why did the Ship Titanic Fail?*, and *Environmentally-Benign Pb-free Solders for Electronic Packaging*.
- I have been quite active in establishing mechanisms for undergraduate research participation. My students have taken part in my NSF Research Experience for Undergraduates (REU) program. Several students have also completed senior theses under my direction through the Barrett Honors College. One former student's work was accepted in a prestigious materials engineering journal and won the Minerals, Metals, and Materials Society Internationals Undergraduate Student Paper contest. I have also strived to recruit women and underrepresented minorities through these programs. I am also engaged in significant amount of general public outreach. Examples include a presentation at the Arizona Science Museum entitled "Why did the Ship Titanic Fail?" Another example has been hosting of a high school teacher to spend the summer conducting research in my laboratory at ASU.
- I'm currently working on a textbook on Metal Matrix Composites, co-authored with Prof. K. Chawla at the University of Alabama at Birmingham. The book is aimed at senior level materials engineering students, graduate students, and practicing engineers. It will be published by Kluwer Academic Publishers in 2003.

Service

I have been involved with a good deal of service, within the university and in the scientific community. I have attempted to be as active in service as possible since it is a critical and important activity. Some highlights are listed below:

- Graduate committee chair of the Materials Engineering Program - I have been actively involved in recruiting graduate students, evaluation of graduate applicants, and revising the graduate curriculum and qualifying examination. I am also member of the Long-Range Strategic Planning Committee (CME), Seminar Committee (CME), and Undergraduate Curriculum Committee (MSE). These efforts have resulted in a significant enhancement in the quality, visibility, and competitiveness of our undergraduate and graduate programs, as well as the department.
- I am a reviewer for the National Science Foundation and thirteen materials engineering journals, including *Acta Materialia*, *Metallurgical and Materials Transactions*, *Composites Science and Technology*, and *Philosophical Magazine*. I've also served as a reviewer for a new edition of a textbook on *Mechanical Metallurgy* by Prof. G. Dieter. I'm serving as guest editor of the *Journal of Light Metals* for a special issue on *Fatigue of Light Metals and Composites*, to be published in 2003.
- I am member of several national societies, and have organized several symposia and been session chair at several national and international conferences. I am also on the board of the ASM International - Phoenix Chapter, secretary of the Composites committee, and chair of the Young Leader's committee of The Minerals, Metals, and Materials Society (TMS). I have been a panelist for several workshops and panels, through the Women and Science and Engineering Program (WISE) at ASU, and the Division of Materials Research at NSF.

My tenure as assistant professor in the Department of Chemical and Materials Engineering (CME) at Arizona State University (ASU) has been very productive and fruitful, both professionally and personally. I hope to continue to refine my teaching and incorporate novel teaching tools and techniques in the classroom, guide students in education and research, conduct and publish high quality research, and provide service to the University and overall scientific community. It is my sincere belief that my efforts and achievements will contribute to enhancing the prestige of our department, college, and university.