MECHANICAL PROPERTIES RESEARCH LABORATORY (MPRL)

1999-2000 Annual Report

Prepared by:

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June 2000

Participating Units:
School of Aerospace Engineering
G.W. Woodruff School of Mechanical Engineering
School of Materials Science and Engineering

College of Engineering
Georgia Institute of Technology
MPRL STATUS & SUMMARY OF 1999-2000 ACCOMPLISHMENTS

The MPRL is an interdisciplinary laboratory which supports research and education programs primarily related to deformation and failure/reliability of structural materials. Its principal activities are directed towards the measurement and modeling of the mechanical properties of engineering materials, particularly those related to deformation, fatigue and fracture. The MPRL has a very direct impact on educational and research programs of the College of Engineering. In its role as an interdisciplinary umbrella organization for experimental research in mechanical properties of materials, the MPRL provides a degree of coordination of equipment usage, training and maintenance that would otherwise be much more costly to the sum of academic units in the conventional university setting of distinctly controlled single investigator equipment. The MPRL has an international reputation for excellence in areas of principal activity, including:

- Fatigue and fracture studies of structural materials, structures and joints
- Development of constitutive equations for deformation and damage, including life prediction methodologies
- Characterization and quantitative analysis of microstructure and damage in engineering materials ranging from structural alloys to composites to lightweight honeycombs and metal foams
- Development of improved constitutive models and simulation capability for materials processing
- Durability and degradation of aging materials and structures

Participating faculty and students are drawn from ME, MSE and AE (Appendix A). The MPRL is administered by the Director, operating in conjunction with an Associate Director and recommendations from a Faculty Governance Board. The External Advisory Board of the School of Materials Science and Engineering also serves as the External Advisory Board of the MPRL, and meets each fall with the Director and a subset of MPRL faculty.

MPRL staff during 1999-00 included:

- MPRL Director (10%)
- MPRL Associate Director (5% time)
- Research Equipment Specialist (R.C. Brown) (40% time)
- Technician (R.Cooper) (33% time)
- Two GRA lab assistants (1/6 time in addition to regular GRA from grants & contracts)
- Secretary (10% time)
- Administrative Assistant (5% time)
MPRL accomplishments during the past year are tabulated as follows (note # faculty reporting is less than total number of MPRL faculty):

<table>
<thead>
<tr>
<th># Faculty Reporting</th>
<th>Published Papers</th>
<th>Presentations</th>
<th>Students Graduated</th>
<th>Faculty &amp; Student Honors &amp; Awards</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>191</td>
<td>99</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>18</td>
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</table>

Although 18 faculty are listed as affiliated with the MPRL, activity in the laboratory for some faculty is rather cyclical in nature. The Table above lists the number of faculty whom were active in the MPRL in 1999-2000 and responded to the request for information for this report (12); hence, it is a conservative estimate of the total productivity of the MPRL. For this set of faculty, approximately $3.23M was expended in externally sponsored research during the past year, for an average of approximately $270K per faculty member. Appendices B and C list the publications and presentations of reporting MPRL faculty from July 1, 1999 to June 10, 2000. Appendix D lists MPRL-related sponsored funding and Appendix E lists major awards bestowed upon reporting MPRL faculty in 1999-00. In addition, at least eight undergraduate students were involved in MPRL research. A total of 13 women and 5 minority students were involved in MPRL research this past year.

MPRL faculty offer a wide range of courses in fatigue, fracture, deformation and damage of engineering materials, mechanics of solids, quantitative image analysis and nondestructive evaluation, and mechanical behavior of materials. The sequence of introductory and advanced applied fracture mechanics courses, cross-listed between ME and MSE, is among the strongest such sequence offered at any U.S. university. A graduate certificate in the Mechanical Properties of Solids is also offered through the MPRL.

**PROGRAM DEVELOPMENT**

Administrative highlights of 1999-00 included the following:

1. The first full year of performance by a new part-time MPRL technician, Robert Cooper, who has assisted with training and maintenance of the MaRC Hi Bay MPRL facilities.
2. Continued to work towards overhead return from Schools (ME and MSE) that dominantly benefit from MPRL to augment flat allocation for operating costs from Dean’s office.
3. Completed MPRL web page update to post standard user forms, MPRL members, reports, strategic plans, etc. on the web and to offer a lab virtual tour.
4. Expended state funds in an amount over $100K to replace non-compliant controllers with date stamp incompatibilities or outmoded platforms (e.g. PDP 11-23 computers on SATEC machines).
Research program development activities included:

1. Continued as a major contributor in the fifth year of the ONR-funded MURI in Integrated Diagnostics (PI/PD W.O. Winer), with five MPRL faculty involved (McDowell, Neu, Saxena, Johnson, Qu) at a level of approximately $270K. The MPRL has offered a core capability to this program in terms of prognostics for fatigue behavior of 4340 and PH 13-8 Mo stainless steels that has been widely recognized among the key contributors.

2. Professors Cochran, Sanders and McDowell have attracted a significant block-funded program in lightweight extruded linear cellular metal alloys, with the mechanical testing component of the program conducted within the MPRL.

3. In 1999-January 2000, MPRL faculty were heavily involved in an NSF Materials Research Science and Engineering Center (MRSEC) proposal in the area of multiscale modeling of fracture in wrought aluminum alloy microstructures. The proposal was not funded.

4. Presently working on IGERT proposal to be submitted in the summer 2000 competition to support graduate students involved at Georgia Tech for research collaboration with European schools through GTL.

5. Ordered an electron backscatter diffraction system (EBSD) to perform orientation imaging of surface grains that will be invaluable for much MPRL work. Also ordered an EDS system for chemical identification. Both systems will be implemented into the recently ordered LEO SEM that will arrive at Georgia Tech in August 2000.

5. Developing sponsored research programs with GE.

**PROGRESS TOWARDS LONG RANGE PLAN GOALS**

**Development of a Leading Position in Mechanical Properties Research**

*Lack of equipment/electronic upgrades:*

Current weaknesses lie in high resolution, in situ imaging capabilities and high precision, low force loading systems. We are working some possibilities to pursue this line of approach.

**Graduate Degree Productivity and Quality**

In view of the size of the MPRL faculty, the Ph.D. production is expected to vary somewhat from year to year, and must be viewed in a time-averaged sense. With the continued maturation of research programs of key new faculty, we expect about 10-12 doctoral graduates per year (about 0.7-0.8 per faculty per year) in steady state given the number of involved faculty members.

A major thrust in the MPRL over the past two years has been improving the quality of graduate students, both in terms of both incoming attributes and value-added in their experience at Tech. Efforts will continue in earnest to place PhDs from the MPRL in positions in leading research universities in the foreseeable future.
Service and Economic Development

Dr. Ashok Saxena’s new textbook entitled “Nonlinear Fracture Mechanics for Engineers” was published by CRC Press in March 1998.

Drs. McDowell and Johnson serve as Editors-in-Chief of major related journals:

McDowell - Technical Editor of the ASME Journal of Engineering Materials and Technology
Johnson - Technical Editor of the ASTM Journal of Composites Technology and Research

Several MPRL participants serve on the editorial boards of key journals in the subject area as well.
APPENDIX A
List of MPRL Faculty

E.A. Armanios, School of Aerospace Engineering - Analysis, design and testing of elastically tailored composite structures, failure characterization and damage modeling of laminated composites, computational solid mechanics.  

J. Cochran, School of Materials Science and Engineering - Processing of lightweight ceramic and metal foams and structures.  

A. Gokhale, School of Materials Science and Engineering - Quantitative fractography and microscopy (stereology), modeling of microstructures, quantitative relationships between microstructure and mechanical behavior of materials.  

I. Jasiuk, G.W. Woodruff School of Mechanical Engineering - Computational, analytical and experimental micromechanics of heterogeneous materials, damage in composite materials with a focus on randomness, mechanics of interfaces/interphases, continuum mechanics.  

W.S. Johnson, School of Materials Science and Engineering/ME - Experimental and analytical characterization of fatigue and fracture behavior of advanced materials including nonlinear and temperature dependent behavior. Development of life prediction methodology.  

W.J. Lackey, G.W. Woodruff School of Mechanical Engineering - Processing of ceramics and ceramic composites using CVI/CVD. Process/structure/property relations for composites and laminated matrix composites.  


D.L. McDowell, G.W. Woodruff School of Mechanical Engineering/MSE - Cyclic plasticity, viscoplasticity, nonlinear and time-dependent fracture mechanics, fatigue and creep-fatigue interaction, finite strain inelasticity, intelligent materials, damage and deformation of metal and ceramic matrix composites.  

S. Melkote, G.W. Woodruff School of Mechanical Engineering - Characterization of the effects of machined surface integrity on fatigue life of hardened bearing steels; constitutive models for high strain, strain rate and temperature processes such as machining.  

R.W. Neu, G.W. Woodruff School of Mechanical Engineering - Thermomechanical fatigue, environmental effects, composite materials, fracture mechanics, creep, fatigue life prediction methods, mechanics of phase transformations.  

J. Qu, G.W. Woodruff School of Mechanical Engineering - Micromechanics of composites, wave propagation and non-destructive evaluation of composites.  

T.H.B. Sanders, School of Materials Science and Engineering - Kinetics of aging of Al alloys; microstructure/property relations.  

A. Saxena, School of Materials Science and Engineering - Fracture mechanics and its application to materials testing and life prediction of structural components, with particular emphasis on high temperature materials and applications involving creep and creep-fatigue loading.  

S. Sitaraman, G.W. Woodruff School of Mechanical Engineering - Thermo-mechanical modeling, reliability, and design of electronic packages.  

S.R. Stock, School of Materials Science and Engineering - Damage accumulation in a wide variety of structural and electronic materials using x-ray diffraction and x-ray computed tomography.  

R. Talreja, School of Aerospace Engineering - Damage durability and nondestructive evaluation of composite materials of polymeric, ceramic and metal matrices, and with fiber architectures ranging from short fibers to long, continuous, woven and braided fibers.  

N. Thadthani, School of Materials Science and Engineering - Materials aspects of dynamic deformation, including fracture and flow behavior of solid and porous materials, synthesis of intermetallics and ceramics materials utilizing effects of high-strain-rate loading.  

M. Zhou, G.W. Woodruff School of Mechanical Engineering - High strain rate behavior of materials, experimental and computational studies of shear banding and deformation of heterogeneous materials  

APPENDIX B
List of Published Papers

A. Gokhale


W. S. Johnson

Journal Papers (refereed)

Refereed Conference Proceedings

W. J. Lackey

Published Books and Parts of Books

Refereed Publications

Daniel L. Jean, Chad E. Duty, Brian T. Fuhrman, and W. Jack Lackey, “Precision LCVD System Design


Other Publications


C. Lynch

Journal Articles


Conference Papers

Lynch, C.S. with Wei Chen and Doru Lupascu “Fracture behavior of ferroelectric ceramics” SPIE 1999 Symposium on Smart Structures and Materials Newport Beach, Ca. March 1999


D.L. McDowell
Refereed Journal Articles


Proceedings


3. Graham, S. and McDowell, D.L., “The Effect of Random Fiber Distribution on the Transverse Thermal Conductivity of Composites with Imperfect Interfaces,” to be presented at SECTAM XX,

**R. Neu**


**J. Qu**


A. Saxena

Books or Book Articles


4. Refereed Conference Proceedings


S. Sitaraman


B2. REFEREED CONFERENCE PUBLICATIONS


B3. INVITED PUBLICATIONS


C. OTHER PUBLICATIONS


R. Talreja

1. Bulsara, V. N., Talreja, R. and Qu, J., "Damage Initiation Under Transverse Loading of


N. Thadhani

JOURNALS


Titanium-silicon Powder Mixture Compacts,” accepted for publication in Metallurgical and Materials Transactions, to be published in March 2000


CONFERENCE PROCEEDINGS


M. Zhou

Refereed Publications:

5. J. Zhai and M. Zhou, “Finite Element Analysis of Micromechanical Failure Modes in Heterogeneous Brittle

Other Publications:

M. Zhou and J. Zhai, Micromechanical Characterization of the Fracture Resistance of A TiB$_2$/Al$_2$O$_3$ Ceramic Composite System, American Ceramic Society 102nd Annual Meeting & Exposition, St. Louis, Missouri, April 30 - May 3, 2000;
J. Zhai and M. Zhou, Micromechanical Modeling of Fracture in Heterogeneous Solids, Proceedings of the Sixth Pan American Congress of Applied Mechanics, pp. 1011-1014, Rio de Janeiro, Brazil, January 4 - 8, 1999;
APPENDIX C

Presentations (not already listed in publications)

A. Gokhale

INVITED PRESENTATIONS


A.M. Gokhale: “Quantitative Characterization of Damage Evolution in Aluminum Alloys”, Sandia National Laboratory, Livermore, CA,


CONTRIBUTED PRESENTATIONS


W. S. Johnson

Invited Presentations
A. FATIGUE 99, Beijing, China, June 1999
B. Durability of Composites, ASME, Blacksburg, VA, June 1999

Contributed Presentations
ASTM, Fatigue of Fasteners, Seattle, May 1999
ASTM, Composites Design, Seattle, May 1999
Adhesion Society, Hilton Head, March 1999
Am Soc of Composites, Dayton, Sept 1999
ICCM-12, Paris, July 1999
Michelin Tire Seminar, Greenville, April 1999

W.J. Lackey

Presentations (Invited)


Other Presentations


C. Lynch
6/99 Two Invited lectures at ENSAM University, Metz, France
8/99 “Smart Materials and Structures” Fourth ARO smart structures workshop, Aug 16-18, 1999
9/99 Invited Participant, AFOSR Strategic Planning Workshop (Maj. Brian Sanders)
10/99 Invited speaker, NSF sponsored workshop on nano and micro mechanics of solids for emerging science and technology, Menlo Park, CA
10/99 Invited Seminar, Purdue University, "Constitutive behavior and reliability of ferroelectric ceramic materials"
10/99 Presentation at Dickerson Middle School, "A Career as an Engineering Professor"

D. McDowell


**R. Neu**


**J. Qu**


A. Saxena

A. Saxena, “Fracture in High Temperature Welds” Seminar presentation at Oak Ridge National Laboratory, July 1999
A. Saxena, “Recent Progress in Nonlinear Fracture Mechanics”, Seminar presentation at Michelin Research Center, Greenville, SC, April 1999
A. Saxena, “Application of Fracture Mechanics in Analyzing Failures”, ASM Atlanta Chapter meeting, November 1999

Contributed Presentations

S. Sitaraman

1. At Northrop-Grumman, Baltimore, MD, Sep. 1, 1999; Presented ‘Application of Commercial Parts and Obsolescence Management (CPOM)’.

2. At IBM, Bromont, Quebec, Canada, Oct. 4, 1999; Presented 'Thermo-Mechanical Modeling and Reliability of Microelectronic Packages'.

3. At Atlanta, Oct. 22, 1999; Presented 'Qualification Guidelines for Electronic Packaging Applications' to Intel Corp.

4. At Fraunhofer IZM (Fraunhofer Institute for Reliability and Microintegration), Berlin, Germany, Oct. 29, 1999; Presented 'Parametric Models for Flip-Chip Assembly - Reliability Study'.

5. At Atlanta, Nov. 9, 1999, Presented ‘Overview of Reliability Research and Flip-Chip Modeling’ to Dr. Tim Ellis and Mr. Gary Schulze, Advanced Polymer Solutions, Willow Grove, PA.

6. At Xerox Palo Alto Research Center, Palo Alto, CA, Jan. 5, 2000; Presented 'Thermal Analysis of Microsping Probes.'


8. At Northrop Grumman, Baltimore, MD, April 5, 2000; Presented ‘Application of Commercial Parts and Obsolescence Management.’

9. At Atlanta, April 20, 2000; Presented ‘Thermo-Mechanical Qualification Guidelines,’ to Dr. Stephen Quander and Dr. Yida Zou, Nokia Research Center, Irving, Texas, and Mr. Tommi Reinkainen, Nokia Mobile Phones, Helsinki, Finland.

R. Talreja


M. Zhou

Micromechanical Characterization of the Fracture Resistance of A TiB₂/Al₂O₃ Ceramic Composite System, 102nd Annual Meeting & Exposition of the American Ceramic Society, St. Louis, MO, April 30 - May 3, 2000;

Damage Growth in FRP laminates under Low Velocity Impact, The 9th U.S.-Japan Conference on Composite Materials, July 3-4, 2000, Mishima, Shizuoka, Japan;
## APPENDIX D
### MPRL-Related External Funding

#### A. Gokhale

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Budget($)</th>
<th>Director</th>
<th>Sponsor</th>
<th>Total Budget</th>
<th>Duration</th>
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<tbody>
<tr>
<td>E-18-X61</td>
<td>$125,000</td>
<td>AMG</td>
<td>USCAR/AFS</td>
<td>$500,000</td>
<td>02/96 to 04/2000</td>
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<td>E-18-X66</td>
<td>$80,000</td>
<td>AMG</td>
<td>NASA</td>
<td>$320,000</td>
<td>05/96 to 05/2000</td>
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<tr>
<td>E-18-T71</td>
<td>$35,000</td>
<td>AMG</td>
<td>Sandia Lab.</td>
<td>$55,000</td>
<td>01/99 to 12/2000</td>
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<tr>
<td>E-18-T73</td>
<td>$99,450</td>
<td>AMG</td>
<td>NSF</td>
<td>$299,000</td>
<td>12/98 to 12/2001</td>
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<td>E-18-T73</td>
<td>$10,000</td>
<td>AMG</td>
<td>NSF</td>
<td>$30,000</td>
<td>06/00 to 05/2002</td>
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(Int. Collaboration)

ALCOA

(GTF grant) $40,000 AMG ALCOA $120,000 No time frame

B08-306 $15,000 AMG Emory-Georgia $15,000 06/99 to 12/99

(joint PI S. Hersh) Tech bio program

TOTAL: $404,450 per year (as PI)

#### W. S. Johnson

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Budget($)</th>
<th>Director</th>
<th>Sponsor</th>
<th>Duration</th>
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<tr>
<td>X85</td>
<td>54K</td>
<td>WSJ</td>
<td>NASA-LaRC</td>
<td>end 8/00</td>
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<tr>
<td>X99</td>
<td>45K</td>
<td>WSJ</td>
<td>LMAS (HSR)</td>
<td>end 3/00</td>
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<tr>
<td>X28</td>
<td>42K</td>
<td>WOW</td>
<td>ONR</td>
<td>soon</td>
</tr>
<tr>
<td>T19</td>
<td>32K</td>
<td>WSJ</td>
<td>CAU (HiPPAC)</td>
<td>3/02</td>
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List of Titles of Projects:

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-31-
1. Hybrid Titanium Composite Laminates
2. Bolt Bearing Behavior in Highly Loaded Composite Joints at Elevated Temperature
3. Small Cracks in PH 13-8
4. Impact of Titanium Laminates

**W.J. Lackey**

Heart Valve Fabrication, $99K, 1/99-6/00

**C. Lynch**

Funding - Grants and Contracts (amounts for 7/1/99 to 6/30/00 only)

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Funding Source</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Constitutive Behavior of Ferroelectric Ceramics</td>
<td>NSF CAREER Award</td>
<td>$50,000</td>
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<tr>
<td>Smart Wing Phase II</td>
<td>DARPA/Northrop</td>
<td>$50,000</td>
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<tr>
<td>PZN Single Crystals</td>
<td>DARPA, TRS Ceramics</td>
<td>$95,000</td>
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<tr>
<td>International Research Collaboration with TU Darmstadt</td>
<td>NSF</td>
<td>$12,500</td>
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**D. McDowell**

Structural Fatigue Task, ONR MURI on Integrated Diagnostics
  Co-PI W.O. Winer (co-PI/PD)
  ONR, $60,000 (DLM component)
Multiaxial Fatigue of Cast A356-T6 Alloy
  USCAR/USAMP Lightweight Vehicle Program
  American Foundryman's Society, $35,000
AASERT New Directions in Modeling Complex Fatigue Phenomena for Condition-Based Maintenance (co-PI R.W. Neu)
  ONR - $35,000
Extruded Metal Honeycomb from Non-Metallic Powders
  DARPA/ONR - $150,000 (DLM Component)
  Co-PIs J.K. Cochran, K.J. Lee and T.H. Sanders, Jr.
Evolving Multiscale Deformation and Damage in Polycrystals
  ARO - $70,000
Crystal Plasticity Study of Fretting Fatigue of Attachments
  UDRI/AF - $50,000 (DLM component)
Co-PI R.W. Neu
AASERT Sliding Mesoscale Models for Polycrystalline Flow and Hardening
ARO - $45,000
total: $445,000

R. Neu

Integrated Diagnostics ONR $65,000
Characteristics of Fretting Fatigue (AASERT) ONR $50,000
Crystallographic Cyclic Plasticity Approaches Applied to Attachment Fatigue Problems UDRI (AF subcontract) $50,000

J. Qu

Thermomechanical Reliability of Electronic Packages (NSF PRC, $60K)
3D Fracture Analysis (ONR CID, $40K)
Laminated Matrix Composites (NSF, $40K)
Physic of Failure in Military Electronics (AFRL, $100K)
Structural Modeling for Electronics Applications (Ford, $63K)

A. Saxena

<table>
<thead>
<tr>
<th>Number</th>
<th>Budget($)</th>
<th>Director</th>
<th>Sponsor</th>
<th>Duration</th>
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<tr>
<td>1.</td>
<td>$50,000</td>
<td>A.Saxena</td>
<td>NSF</td>
<td>4/93-12/99</td>
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<td>2.</td>
<td>$35,000</td>
<td>Ward Winer</td>
<td>ONR</td>
<td>3/95-5/2000</td>
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<td>3.</td>
<td>$30,000</td>
<td>A.Saxena</td>
<td>Rolls Royce</td>
<td>1/98-5/2001</td>
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S. Sitaraman

1. Title and Miniaturization
   Organization Funding NSF - CAREER
   PI S. K. Sitaraman
   Co-PI None
<table>
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<tr>
<th>Project Description</th>
<th>PI(s)</th>
<th>Co-PI(s)</th>
<th>Organization Funding</th>
<th>Level of Funding</th>
<th>Date</th>
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<tr>
<td>7. Novel, Compliant Nano-Scale Spring Interconnects</td>
<td>S. K. Sitaraman</td>
<td>None</td>
<td>Semiconductor Research Corporation</td>
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</table>
8. Title: Microspring Testing and Analysis  
Organization Funding: Xerox University Affairs Committee  
PI: S. K. Sitaraman  
Co-PI: None  
Level of Funding: $60,000/4 years; First-year $15,000 approved  
Date: Sep. 1999 – Aug. 2003

9. Title: Low-Cost Electronic Packaging  
Organization Funding: National Science Foundation – Packaging Research Center  
PI: S. K. Sitaraman  
Co-PI: None  
Level of Funding: $232,000  
Date: January 1995 - December 2000

10. Title: Flexible Flip-Chip Connection (Out-of-Box/PRC)  
Organization Funding: NSF – Packaging Research Center  
PI: S. K. Sitaraman  
Co-PI: Don McBride, C. P. Wong (MSE), and J. Qu  
Level of Funding: $37,500  
Date: October 1997 – October 1999

11. Title: Computer-Based Models for Determining Thermo-Mechanical Reliability of Fiber-Optic Cable Connectors  
Organization Funding: Lucent Technologies, Inc.  
PI: S. K. Sitaraman  
Co-PI: None  
Level of Funding: $35,000  
Date: November 1996 – June 2000

12. Title: Distributed Collaborative Engineering System for Electronic Packages  
Organization Funding: AT&T Foundation and Lucent Technologies Foundation  
PI: S. K. Sitaraman  
Co-PI: R. Fulton and R. Peak  
Level of Funding: $30,000  
Date: November 1996 - June 2000

R. Talreja

1. “A Synergistic Damage Mechanics Approach to Durability of Composite Structures”, Army
Research Office, $52,217


**N. Thadhani**

<table>
<thead>
<tr>
<th>Number</th>
<th>~FY’00 Total</th>
<th>Co-P.I.</th>
<th>Sponsor</th>
<th>Duration</th>
<th>Title*</th>
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<tbody>
<tr>
<td>E18T07</td>
<td>$90,000</td>
<td>ARO</td>
<td>6/97-5/00</td>
<td>(i)</td>
<td>Synthesis of Intermetallic-Ceramic Composites with Ultra-fine Grain Micro-structures (Total $300,000 - 3-years)</td>
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<tr>
<td>E18T46</td>
<td>$52,000</td>
<td>DoD/Assert</td>
<td>4/98-3/01</td>
<td>(ii)</td>
<td>Shock Compaction and Synthesis of Ti3SiC2 Ternary Carbide (Total $155,000, 3 yrs)</td>
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<tr>
<td>E18T58</td>
<td>$70,000</td>
<td>Zhou</td>
<td>ARO</td>
<td>8/98-7/01</td>
<td>(iii) Processing and Dynamic Behavior of Microstructurally-biased TiB$_2$+Al$_2$O$_3$ Ceramic (Total $306,000 - 3 years plus $60,000 cost share)</td>
</tr>
<tr>
<td>E18T83</td>
<td>$75,000</td>
<td>Gokhale</td>
<td>NSF/REU+RET</td>
<td>3/99-2/02</td>
<td>(iv) NSF Research Experiences for Undergraduate Program Site (Total $165,000 for 3 years + $24,000 cost share + $37,500 1-year supplement for RET program)</td>
</tr>
</tbody>
</table>

(i) Synthesis of Intermetallic-Ceramic Composites with Ultra-fine Grain Micro-structures (Total $300,000 - 3-years)

(ii) Shock Compaction and Synthesis of Ti3SiC2 Ternary Carbide (Total $155,000, 3 yrs)

(iii) Processing and Dynamic Behavior of Microstructurally-biased TiB$_2$+Al$_2$O$_3$ Ceramic (Total $306,000 - 3 years plus $60,000 cost share)

(iv) NSF Research Experiences for Undergraduate Program Site (Total $165,000 for 3 years + $24,000 cost share + $37,500 1-year supplement for RET program)

**M. Zhou**

Time-Resolved Analysis of the Dynamic Behavior of Granular Materials, AFOSR, $60,000;
Dynamic Failure Resistance of Metals and Composites, ONR, $37,700;
AASERT: Constitutive and Failure Behavior of Granular Materials, AFOSR, $33,000;
Impact Damage and Residual Strength of Structural Composites, ONR/CAU, $50,000;
Processing, Microstructure, High Performance Behavior Correlation in an Engineered Material, ARO, $80,000;
Modelling and Characterization of Microstructure-induced Toughening in Advanced Ceramic Composites with Multiple Micro and Nano Size Scales, NSF-CAREER program, $50,000
APPENDIX E
Honors and Awards

A. Gokhale

2. Manish Dighe received Sigma Xi best MS thesis award
3. Sigma Xi Sustained Research award (April 2000)

W.S. Johnson

Editor-in-Chief, Journal of Composites Technology and Research

W.J. Lackey


D. McDowell

2. Member of U.S. National Committee on Theoretical and Applied Mechanics, administered by the National Research Council (ASTM representative), 1994-present.
4. Elected as a member of the M&IE Alumni Board for 1999-2002, Dept. of Mechanical and Industrial Engineering, University of Illinois at Urbana-Champaign.
5. Georgia Tech Outstanding Doctoral Thesis Advisor Award, 2000, in recognition of the achievements of a faculty member’s doctoral students who completed all degree requirements from January 1, 1995 to December 31, 1999.
A. Saxena
Co-Principal Editor, Fatigue of Engineering Materials and Structures, an International Journal
ASTM Award of appreciation for superior leadership in Committee E-08 on Fatigue and Fracture
Member, Editorial Board, Engineering Fracture Mechanics

S. Sitaraman
NSF CAREER Award - 1997-2001

R. Talreja
1. Regional Editor for Mechanics of Materials
2. Member of the Editorial Board, International Journal of Materials & Product Technology

M. Zhou
NSF CAREER 2000-2004
MPRL STUDENTS GRADUATED

A. Gokhale

Asim Tewari Ph.D.  Winter 1997  Winter 1999
S. Yang Ph.D.  Fall 1994  Spring 1999
Thomas Mirabelli MS  Fall 1997  Fall 1999

W.S. Johnson

Don Rhymer MS/ME 9/98 12/99
Carol Burke MS/MSE 1/98 12/99

C. Lynch

Wei Chen, PhD
Jacqueline Menchaca, MS
Benoit Rivollet, MS

D. McDowell

V. Bennett, PhD, Graduated Summer Qtr, 1999
G.C. Butler, PhD (co-advisor S.R. Stock), Graduated Summer Qtr, 1999
S. Graham, PhD, Graduate Summer Qtr., 1999

R.W. Neu

M.S.:

Vincent Barre Determination of a Local Damage Threshold Criterion for a Laminate Glass/Epoxy under an Intermediate Rate of Loading, Winter 1999

Thomas de Vaulx, Determination of the First Damage Criterion of a Glass/Epoxy Composite Material Using an In-situ Test System, Winter 1999

Michael W. Woodmansee, Thermal Cycling and Rate-Dependent Stress Relaxation Behavior of Solders, Spring 1999


J. Qu

Matthew Yao, PhD, Spring 2000
A. Saxena
Adam Bluteau  MS  9/98  12/99
James Lane  MS  9/98  8/99

S. Sitaraman
Stelios Michaleides  PhD  8/95  8/99
Carlton Hanna  MS  9/97  5/99
B. Namemanjula Surendran Vareyam  M.S.  8/97  8/99

N. Thadhani
Kevin Vandersall  Ph.D  Oct 1995  Graduated Dec’99  Post-doc at Lawrence Livermore National Lab

M. Zhou
J. Zhai, PhD, Graduated January 2000