Final Progress Report for Research Projects Funded by Health Research Grants

Instructions: Please complete all of the items as instructed. Do not delete instructions. Do not leave any items blank; responses must be provided for all items. If your response to an item is "None", please specify "None" as your response. "Not applicable" is not an acceptable response for any of the items. There is no limit to the length of your response to any question. Responses should be single-spaced, no smaller than 12-point type. The report **must be completed using MS Word**. Submitted reports must be Word documents; they should not be converted to pdf format. Questions? Contact Health Research Program staff at 717-783-2548.

1. **Grantee Institution:** Temple University of the Commonwealth System of Higher Education

2. **Reporting Period (start and end date of grant award period):** 01/01/2009 – 12/31/2012

3. **Grant Contact Person (First Name, M.I., Last Name, Degrees):** Germaine A Calicat, MLA

4. **Grant Contact Person's Telephone Number:** 215.204.7655

5. **Grant SAP Number:** 4100047651

6. **Project Number and Title of Research Project:** 7 – Biometric Composite Design

7. **Start and End Date of Research Project:** 5/1/2009 – 5/31/2010

8. **Name of Principal Investigator for the Research Project:** George R. Baran, PhD

9. **Research Project Expenses**.

   9(A) Please provide the total amount of health research grant funds spent on this project for the entire duration of the grant, including indirect costs and any interest earned that was spent:

   $ 50,000

   9(B) Provide the last names (include first initial if multiple individuals with the same last name are listed) of **all** persons who worked on this research project and were supported with health research funds. Include position titles (Principal Investigator, Graduate Assistant, Post-doctoral Fellow, etc.), percent of effort on project and total health research funds expended for the position. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name	Position Title	% of Effort on Project	Cost
Wang	Post-doctoral fellow	100	$ 40,333.33

9(C) Provide the names of **all** persons who worked on this research project, but who *were not* supported with health research funds. Include position titles (Research Assistant, Administrative Assistant, etc.) and percent of effort on project. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name	Position Title	% of Effort on Project
Baran	PI	<1%

9(D) Provide a list of **all** scientific equipment purchased as part of this research grant, a short description of the value (benefit) derived by the institution from this equipment, and the cost of the equipment.

Type of Scientific Equipment	Value Derived	Cost
None		

10. Co-funding of Research Project during Health Research Grant Award Period. Did this research project receive funding from any other source during the project period when it was supported by the health research grant?

Yes_____ No _____X___

If yes, please indicate the source and amount of other funds:

11. Leveraging of Additional Funds

11(A) As a result of the health research funds provided for this research project, were you able to apply for and/or obtain funding from other sources to continue or expand the research?

Yes_____ No ____X_____

If yes, please list the applications submitted (column A), the funding agency (National Institutes of Health—NIH, or other source in column B), the month and year when the application was submitted (column C), and the amount of funds requested (column D). If you have received a notice that the grant will be funded, please indicate the amount of funds to be awarded (column E). If the grant was not funded, insert "not funded" in column E.

Do not include funding from your own institution or from CURE (tobacco settlement funds). Do not include grants submitted prior to the start date of the grant as shown in Question 2. If you list grants submitted within 1-6 months of the start date of this grant, add a statement

below the table indicating how the data/results from this project were used to secure that grant.

A. Title of research project on grant application	B. Funding agency (check those that apply)	C. Month and Year Submitted	D. Amount of funds requested:	E. Amount of funds to be awarded:
None	☐NIH ☐ Other federal (specify:_____) ☐ Nonfederal source (specify:_)		$	$

11(B) Are you planning to apply for additional funding in the future to continue or expand the research?

Yes_____ No ___X_____

If yes, please describe your plans:

12. Future of Research Project. What are the future plans for this research project?

We are hoping to obtain experimental data to support the modeling effort.

13. New Investigator Training and Development. Did students participate in project supported internships or graduate or post-graduate training for at least one semester or one summer?

Yes_____ No _____X_____

If yes, how many students? Please specify in the tables below:

	Undergraduate	Masters	Pre-doc	Post-doc
Male				
Female				
Unknown				
Total				

	Undergraduate	Masters	Pre-doc	Post-doc
Hispanic				
Non-Hispanic				
Unknown				
Total				

	Undergraduate	Masters	Pre-doc	Post-doc
White				
Black				
Asian				
Other				
Unknown				
Total				

14. Recruitment of Out-of–State Researchers. Did you bring researchers into Pennsylvania to carry out this research project?

Yes_____ No ____X_____

If yes, please list the name and degree of each researcher and his/her previous affiliation:

15. Impact on Research Capacity and Quality. Did the health research project enhance the quality and/or capacity of research at your institution?

Yes_____ No _____X_____

If yes, describe how improvements in infrastructure, the addition of new investigators, and other resources have led to more and better research.

16. Collaboration, business and community involvement.

16(A) Did the health research funds lead to collaboration with research partners outside of your institution (e.g., entire university, entire hospital system)?

Yes_____ No ____X_____

If yes, please describe commercial development activities that resulted from the research project:

16(B) Did the research project result in commercial development of any research products?

Yes_____ No___X_____

If yes, please describe commercial development activities that resulted from the research project:

16(C) Did the research lead to new involvement with the community?

Yes_____ No ___X_____

If yes, please describe involvement with community groups that resulted from the research project:

17. Progress in Achieving Research Goals, Objectives and Aims.

List the project goals, objectives and specific aims (as contained in the grant agreement). Summarize the progress made in achieving these goals, objectives and aims for the period that the project was funded (i.e., from project start date through end date). Indicate whether or not each goal/objective/aim was achieved; if something was not achieved, note the reasons why. Describe the methods used. If changes were made to the research goals/objectives/aims, methods, design or timeline since the original grant application was submitted, please describe the changes. Provide detailed results of the project. Include evidence of the data that was generated and analyzed, and provide tables, graphs, and figures of the data. List published abstracts, poster presentations and scientific meeting presentations at the end of the summary of progress; peer-reviewed publications should be listed under item 20.

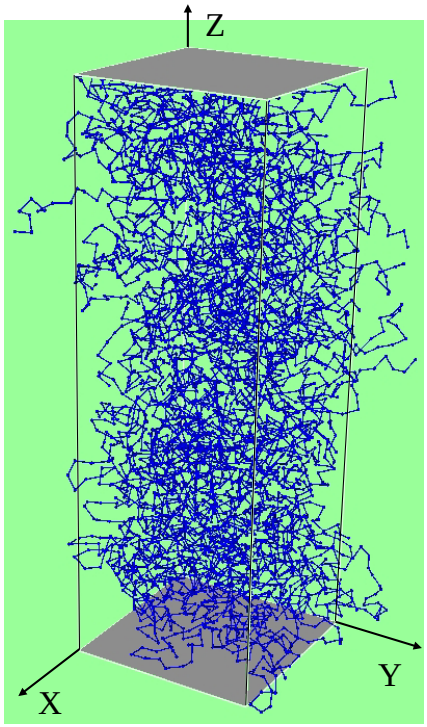
This response should be a DETAILED report of the methods and findings. It is not sufficient to state that the work was completed. Insufficient information may result in an unfavorable performance review, which may jeopardize future funding. If research findings are pending publication you must still include enough detail for the expert peer reviewers to evaluate the progress during the course of the project.

Health research grants funded under the Tobacco Settlement Act will be evaluated via a performance review by an expert panel of researchers and clinicians who will assess project work using this Final Progress Report, all project Annual Reports and the project's strategic plan. After the final performance review of each project is complete, approximately 12-16 months after the end of the grant, this Final Progress Report, as well as the Final Performance Review Report containing the comments of the expert review panel, and the grantee's written response to the Final Performance Review Report, will be posted on the CURE Web site.

There is no limit to the length of your response. Responses must be single-spaced below, no smaller than 12-point type. If you cut and paste text from a publication, be sure symbols print properly, e.g., the Greek symbol for alpha (α) and beta (ß) should not print as boxes (□) and include the appropriate citation(s). DO NOT DELETE THESE INSTRUCTIONS.

The goal of the research was to design structural composites that take advantage of the strategy used by molluscs to create tough and strong shells. In the sea shells, energy-absorbing capabilities proteins join individual plates of the mineral aragonite, which although being intrinsically weak, forms a tough and strong composite when the proteins are present.

We first sought to model bio-mimicking proteins using molecular dynamics in order to eventually optimize composite design. We successfully built a polymer network bead-spring model in OCTA (molecular dynamics software) [Aoyagi, T., et al., *A general-purpose coarse-grained molecular dynamics program.* Computer Physics Communications, 2002. **145**(2): p. 267-279] as shown in Figure 1 on the right. The system consisted of M=100 linear polymers made of N=40 beads confined between two walls simulating plates of aragonite. The unit cell had a size of 11.71 X 11.71 X 35.0 σ (σ is two-thirds of the maximum extension of the spring). The size of the unit cell, the number of polymer chains within the system M, and the degree of polymerization N could easily be changed to account for the thickness of the interphase proteins, and the actual molecular weight distribution as determined experimentally.



In order to simulate the elastic mechanical behavior of the polymer network, it is necessary to know the interaction potentials of the bead-bead and bead-wall segments. The WLC (Worm-Like-Chain) potential function used in our previous, single polymer chain study was applied here [Wang, W.H., et al., *Molecular dynamics simulation of AFM studies of a single polymer chain.* Physics Letters A, 2008. **372**(47): p. 7007-7010].

We turned to a macro-model analyzed by finite elements. Fracture toughness and failure processes in particle- and fiber-reinforced composites are related to the basic problem of a crack interacting with a second phase particle or fiber. In this study, a small zone at the center of a typical single-edge notch 3-point bending specimen used in toughness measurements was selected as the area of interest. A detailed representation of microstructure is shown in Figure 2, including particle, matrix and interphases. Two types of interphases were compared: nacre-protein-analogue material (beta-peptide), and traditional silane. The volume content of particles in the unit cell is 55%.

We use a progressive damage degradation material model to simulate crack propagation. As shown in Figure 3, this model included an undamaged response, a damage initiation criterion, and a damage evolution response. Three parameters (Young's modulus, Poisson's ratio and yield strength) defined the undamaged response of the material. A ductile damage initiation criterion was used in the simulation. The damage initiation strain under tensile load is derived from the fracture strain. For the matrix material, it is assumed to be 0.04. We are not aware of any specific reference in the literature that documents a direct measurement of fracture strain of silane. Therefore, its damage initiation strain is derived from fiber pull-out experiment force displacement curves shown in the references in Table 1. We chose the fracture strain in tension

to be in the range of 2-7%.

The damage evolution law describes the rate of degradation of material stiffness once the corresponding initiation criterion has been reached. It manifests itself in two ways: reduction of the yield stress, and elasticity (stiffness). The rate of the degradation is controlled by another material parameter G_0, the energy required to open a unit area of crack. The G_0 value varies in the range of $0.05 - 0.1\ Jm^{-2}$ for polymer matrix-filler interphase bond failure. The matrix material property was set as $0.1\ Jm^{-2}$ in the simulation. The G_0 value for the silane interphase material was selected according to the critical energy release rate G_{ic} measured during fiber pull-out experiments.

The parameters chosen for newly developed beta-peptide interphase materials reflect the nanoscale mechanisms associated with organic layers (biopolymer) found in nacre. Experimental data indicate that the force-extension behavior of biopolymer exhibited an irregular "saw-tooth" character. It has significant stretching capability and can maintain cohesion between nacre tablets over a large range during tablet sliding. This thin layer of biopolymer can be seen as a series of nonlinear springs that connect the faces of the tablets. Stretching of the springs (organics ligaments) controls the behavior of the interphase under tension and shear.

Note that the experimental data illustrate the large stretching capability of individual polymer chains, but might not be representative of the confined biopolymer at the interface. When a bundle of polymer chains is considered, the ensemble average constitutive response is likely to exhibit an approximately constant strength over the range of displacements. In the absence of further experimental data on the nanoscale mechanical response of the confined beta-peptide layer at the interface, it is reasonable to assume that the constitutive behavior of beta-peptide interphase can be derived from polymer network simulations. In this study, parameters used in the progressive damage material model were derived from a three-dimensional macromolecular network solid model analysis. This approach is briefly described below.

The force extension behavior of a single polymer chain can be represented by a free-jointed-chain (FJC) model or a worm-like-chain (WLC) model and can be derived based on single polymer chain atomic force spectroscopy tests. Using statistical mechanics, the single polymer chain behavior can be incorporated into a three-dimension macromolecular "eight-chain" network. This network idealization captures the essential features of a random network in an "average" sense. The simulation for a macromolecular network shows the stress-strain behavior of the material undergoes a nonlinear increase, then transitions to a plateau region, and finally increases again at large stretches. Our constitutive model well captures the first transition from a nonlinear increase to the plateau region, which corresponds to triggering of the unfolding of individual polymer chains. According to the nominal stress *vs* stretch behavior in simple tension of a modular three-dimensional network representing the organic matrix in nacre [H.J. Qi et al., Mechanics of Biological Tissues, p. 175 (2005)], the damage initiation strain for beta-peptide interphase material is chosen to be in the range of 5-20 and the G_0 value is chosen to be 1500-2000 Jm^{-2}. Detailed parameter values are listed in Table 1.

The boundary conditions applied in the study zone are derived from a macroscopic 3-point bending simulation. We calculated the actual deformation gradient for a small square region in

front of the crack tip during 3-point bending, then mapped onto current microscopic unit cell simulations as the displacement loading condition. A convergence study was carried out to ensure that the number of elements in the model was adequate. There are approximately 52000 nodes and 105000 elements in the final model.

Our special interest area is the region surrounding the crack tip, where the energy is predominantly dissipated. Figure 4 compares the von Mises Stress as the crack propagates toward the embedded particles. The initial crack tip has a distance of r (r is the particle radius) away from the first particle. As shown in Figure 4a, as the crack start to propagate in the composite with a beta-peptide interphase at 0.3 seconds, a stress concentration occurs only at the crack tip. Before the crack 'senses' the first particle, dissipation of energy by the creation of new surfaces relaxes stresses in regions other than at the crack tip. The beta-peptide interphase material provides continuous stress transfer between matrix and particle. As the crack approaches the first particle at approximately 0.44 seconds, a large stress concentration area between crack tip and the particle is built up. Even though the maximum stress is observed at the particle surface, the crack does not grow in that direction. Instead, it propagates within the matrix material and is deflected around the particle. Once the crack propagates forward again, the stress concentration in the area around the particle starts to decrease again. Once the crack passes the particle, it continues to propagate within the matrix. During this procedure, the crack propagation speed decreases dramatically when the crack interacts with the first particle. This is not observed in composites with the silane interphase. Even though the silane interphase also provides continuous stress transfer between particle and matrix, a large stress concentration area is not observed when the crack approaches the first particle. Comparing the crack length at the final stage (1.0 seconds), the composite with a beta-peptide interphase (Figure 4a) leads to a lower crack growth distance than that the composite with a silane interphase (Figure 4b) under the same loading conditions.

As shown in Figure 5, normalized damage dissipation energy decreases when the crack starts to interact with particles in composites with a beta-peptide interphase. Composites with a silane interphase do not show the same behavior. The normalized damage dissipation energy increases monotonically. The decrease of normalized damage dissipation energy observed in composites with beta-peptide interphases indicates that the growth of the crack is retarded.

The 2D FEM unit cell simulation results indicate that particle-reinforced polymer composites with a more compliant and stretchable interphase will help in absorbing local strain energy while remaining intact, causing less damage within the matrix. As a result, this type of interphase decreases crack propagation speed and results in an increase of fracture toughness.

Table 1. Material properties of composite components

Material	Young's modulus E (MPa)	Poisson's ratio	Yield stress (MPa)	Crack initiation strain under tensile load	$G_0(Jm^{-2})$	References
E-Glass particle	75000	0.24	N/A	N/A	N/A	C.J. Sun et al., Composites Part A, 38,80 (2007).
BisGMA/ TEGDMA resin matrix	2000	0.35	70	0.04	0.1	D.L. Zhao et al., Dental Materials, 13, 198 (1997).
Interphase material A (Silane)	7000	0.32	70	2-7	20-40	R. Plonka et al., Composites Part A, 35,1207 (2007). S.K. Khanna et al., Transactions of the ASME, 125, 90 (2003).
Interphase material B (beta-peptide)	160-2000	0.35-0.45	750	5-20	1500-2000	H.J. Qi et al., Mechanics of Biological Tissues, p175 (2005). P.K.V.V. Nukala et al. Biomaterials, 26, 30 (2005).

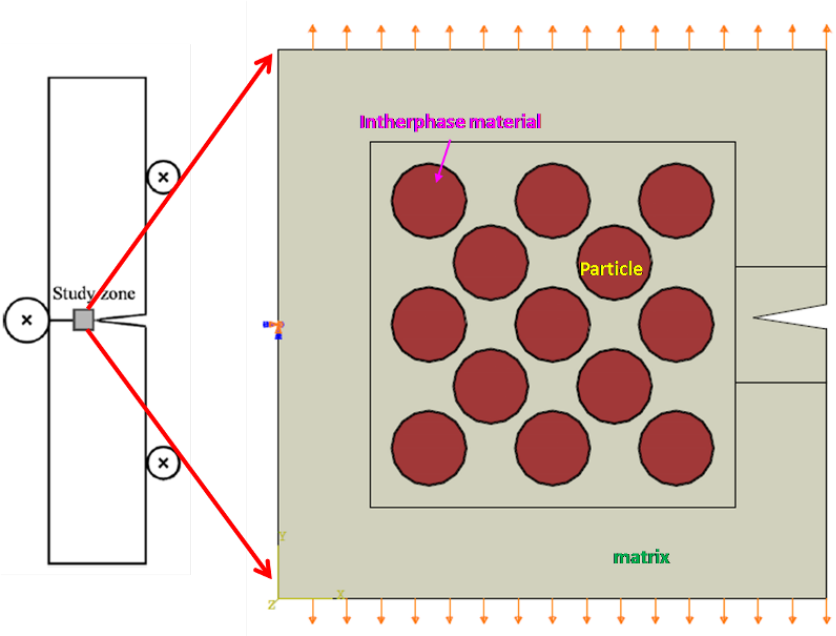


Figure 2. Schematic representations of 3-point bend specimen (left) and study zone (right).

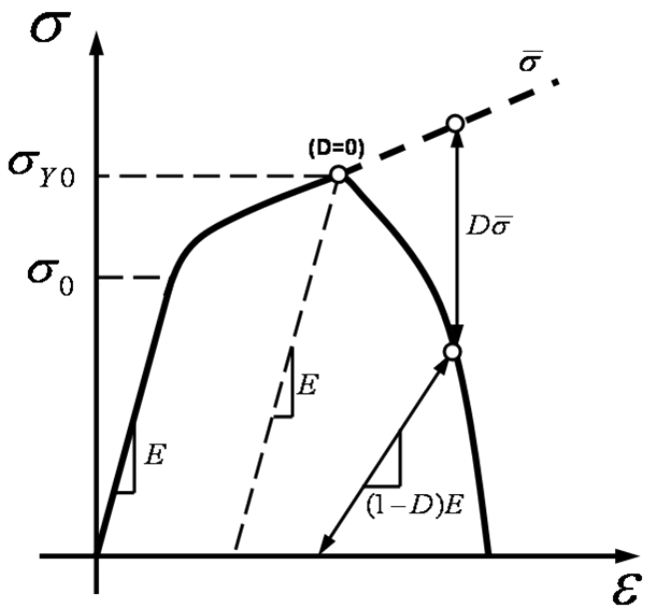
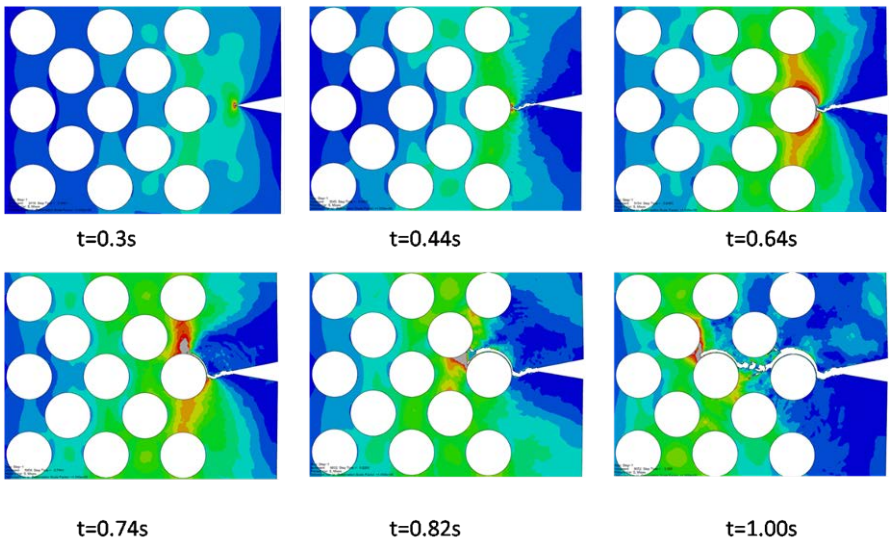


Figure 3. Stress-strain curves with progressive damage degradation used in the FEM simulation.

(a)



(b)

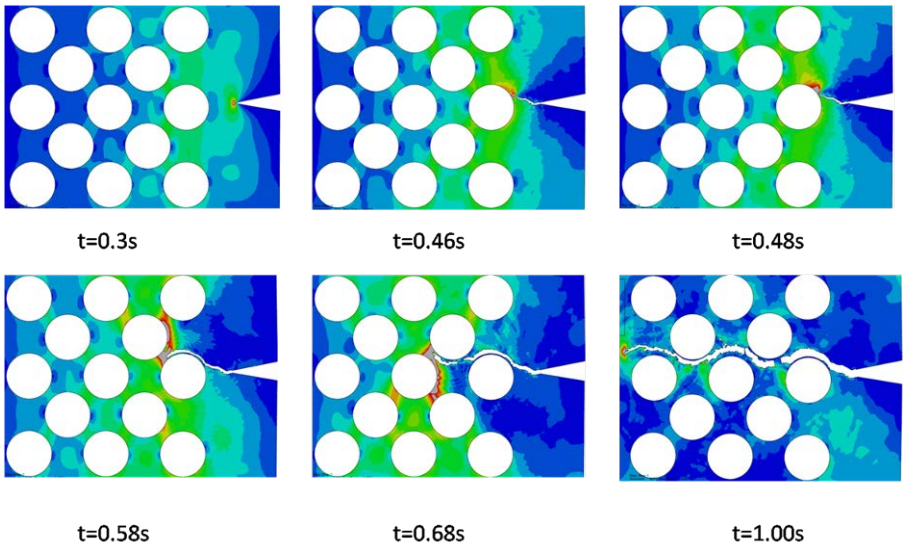


Figure 4. Von Mises stress evolution as the crack propagates around particles; (a) composite with beta-peptide interphase; (b) composite with silane interphase.

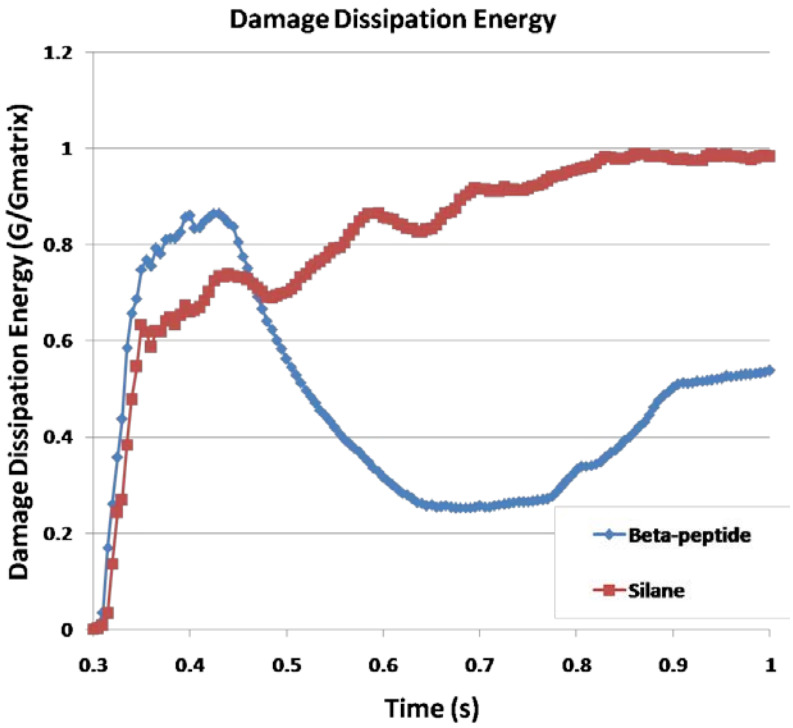


Figure 5. Normalized damage dissipation energy evolution as the crack interacts with particles.

18. Extent of Clinical Activities Initiated and Completed. Items 18(A) and 18(B) should be completed for all research projects. If the project was restricted to secondary analysis of clinical data or data analysis of clinical research, then responses to 18(A) and 18(B) should be "No."

18(A) Did you initiate a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

_____Yes
___X__ No

18(B) Did you complete a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

_____Yes
___X__ No

If "Yes" to either 18(A) or 18(B), items 18(C) – (F) must also be completed. (Do NOT complete 18(C-F) if 18(A) and 18(B) are both "No.")

18(C) How many hospital and health care professionals were involved in the research project?

_____Number of hospital and health care professionals involved in the research project

18(D) How many subjects were included in the study compared to targeted goals?

_____Number of subjects originally targeted to be included in the study
_____Number of subjects enrolled in the study

Note: Studies that fall dramatically short on recruitment are encouraged to provide the details of their recruitment efforts in Item 17, Progress in Achieving Research Goals, Objectives and Aims. For example, the number of eligible subjects approached, the number that refused to participate and the reasons for refusal. Without this information it is difficult to discern whether eligibility criteria were too restrictive or the study simply did not appeal to subjects.

18(E) How many subjects were enrolled in the study by gender, ethnicity and race?

Gender:
_____Males
_____Females
_____Unknown

Ethnicity:
_____Latinos or Hispanics
_____Not Latinos or Hispanics
_____Unknown

Race:
_____American Indian or Alaska Native
_____Asian
_____Blacks or African American
_____Native Hawaiian or Other Pacific Islander
_____White
_____Other, specify:_____
_____Unknown

18(F) Where was the research study conducted? (List the county where the research study was conducted. If the treatment, prevention and diagnostic tests were offered in more than one county, list all of the counties where the research study was conducted.)

19. Human Embryonic Stem Cell Research. Item 19(A) should be completed for all research projects. If the research project involved human embryonic stem cells, items 19(B) and 19(C) must also be completed.

19(A) Did this project involve, in any capacity, human embryonic stem cells?
_____ Yes
___X__ No

19(B) Were these stem cell lines NIH-approved lines that were derived outside of Pennsylvania?

_____Yes
_____ No

19(C) Please describe how this project involved human embryonic stem cells:

20. Articles Submitted to Peer-Reviewed Publications.

20(A) Identify all publications that resulted from the research performed during the funding period and that have been submitted to peer-reviewed publications. Do not list journal abstracts or presentations at professional meetings; abstract and meeting presentations should be listed at the end of item 17. **Include only those publications that acknowledge the Pennsylvania Department of Health as a funding source** (as required in the grant agreement). List the title of the journal article, the authors, the name of the peer-reviewed publication, the month and year when it was submitted, and the status of publication (submitted for publication, accepted for publication or published.). Submit an electronic copy of each publication or paper submitted for publication, listed in the table, in a PDF version 5.0.5 (or greater) format, 1,200 dpi. Filenames for each publication should include the number of the research project, the last name of the PI, the number of the publication and an abbreviated research project title. For example, if you submit two publications for PI Smith for the "Cognition and MRI in Older Adults" research project (Project 1), and two publications for PI Zhang for the "Lung Cancer" research project (Project 3), the filenames should be:

Project 1 – Smith – Publication 1 – Cognition and MRI
Project 1 – Smith – Publication 2 – Cognition and MRI
Project 3 – Zhang – Publication 1 – Lung Cancer
Project 3 – Zhang – Publication 2 – Lung Cancer

If the publication is not available electronically, provide 5 paper copies of the publication.

Note: The grant agreement requires that recipients acknowledge the Pennsylvania Department of Health funding in all publications. Please ensure that all publications listed acknowledge the Department of Health funding. If a publication does not acknowledge the funding from the Commonwealth, do not list the publication.

Title of Journal Article:	Authors:	Name of Peer-reviewed Publication:	Month and Year Submitted:	Publication Status (check appropriate box below):
1. None				☐Submitted ☐Accepted ☐Published

20(B) Based on this project, are you planning to submit articles to peer-reviewed publications in the future?

Yes_____ No ____X_____

If yes, please describe your plans:

21. Changes in Outcome, Impact and Effectiveness Attributable to the Research Project. Describe the outcome, impact, and effectiveness of the research project by summarizing its impact on the incidence of disease, death from disease, stage of disease at time of diagnosis, or other relevant measures of outcome, impact or effectiveness of the research project. If there were no changes, insert "None"; do not use "Not applicable." Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

None

22. Major Discoveries, New Drugs, and New Approaches for Prevention Diagnosis and Treatment. Describe major discoveries, new drugs, and new approaches for prevention, diagnosis and treatment that are attributable to the completed research project. If there were no major discoveries, drugs or approaches, insert "None"; do not use "Not applicable." Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

None

23. Inventions, Patents and Commercial Development Opportunities.

23(A) Were any inventions, which may be patentable or otherwise protectable under Title 35 of the United States Code, conceived or first actually reduced to practice in the performance of work under this health research grant? Yes_____ No___X_____

If "Yes" to 23(A), complete items a – g below for each invention. (Do NOT complete items a - g if 23(A) is "No.")

a. Title of Invention:

b. Name of Inventor(s):

c. Technical Description of Invention (describe nature, purpose, operation and physical, chemical, biological or electrical characteristics of the invention):

d. Was a patent filed for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No___

If yes, indicate date patent was filed:

e. Was a patent issued for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No___
If yes, indicate number of patent, title and date issued:
Patent number:
Title of patent:
Date issued:

f. Were any licenses granted for the patent obtained as a result of work performed under this health research grant? Yes_____ No___

If yes, how many licenses were granted?_____

g. Were any commercial development activities taken to develop the invention into a commercial product or service for manufacture or sale? Yes__ No___

If yes, describe the commercial development activities:

23(B) Based on the results of this project, are you planning to file for any licenses or patents, or undertake any commercial development opportunities in the future?

Yes_____ No ____X_____

If yes, please describe your plans:

24. Key Investigator Qualifications. Briefly describe the education, research interests and experience and professional commitments of the Principal Investigator and all other key investigators. In place of narrative you may insert the NIH biosketch form here; however, please limit each biosketch to 1-2 pages. *For Nonformula grants only – include information for only those key investigators whose biosketches were not included in the original grant application.*

BIOGRAPHICAL SKETCH

Provide the following information for the key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

NAME	POSITION TITLE
George R. Baran	Associate Dean, Engineering and Director, Center for Bioengineering and Biomaterials
eRA COMMONS USER NAME GRBARAN	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
University of Michigan, Ann Arbor MI	BSE	1972	Metallurgy
University of Michigan, Ann Arbor MI	MSE	1973	Materials Engineering
University of Michigan, Ann Arbor MI	PhD	1976	Materials Engineering and Dental Materials

A. Positions and Honors.

Positions and Employment

1978-1983	Assistant Professor, Temple University School of Dentistry, Philadelphia, PA
1981-	Member, Graduate Faculty, Temple University, Philadelphia, PA
1983-1991	Associate Professor, Temple University School of Dentistry, Philadelphia, PA
1991-1999	Professor, Temple University School of Dentistry, Philadelphia, PA
1995-1996	Biologist, Harvard School of Medicine, Charlestown, MA
1999-2002	Adjunct Professor, University of Pennsylvania School of Dentistry, Philadelphia, PA
1999-2000	Acting Chair, Department of Chemistry, Temple University, Philadelphia, PA
1999-	Professor, Mechanical Engineering, Temple University, Philadelphia, PA
1999-	Director, Center for Bioengineering and Biomaterials, Temple University, Philadelphia, PA
2003-	Visiting Research Professor, Drexel University, Philadelphia, PA
2004-	Associate Dean, College of Engineering, Temple University, Philadelphia, PA
2006-	Adjunct Professor (Chemistry), Temple University

Other Experience and Professional Memberships

1978-	Member, International Association for Dental Research
1983-	Member, Academy of Dental Materials
1988, '89, '90	Chair, site visit Study Sections for review of Phase II SBIR grant applications
1990-	Member, American Association for the Advancement of Science
1990	Program Chair, Dental Materials Group
1991-1994	Secretary, Dental Materials Group Chapter-America
1995-1996	President, Dental Materials Group Chapter-America
1991-1995	Member, OBM-2 Study Section
1995-	Member, Society for Biomaterials

1994-1999	Member, Editorial Board, Journal of Dental Research
1999-2004	Member, OBM-1 Study Section
2001	Reviewer, Connecticut Innovations grant program
2001	Reviewer, U.S. Civilian Research and Development Cooperative Grants Program
2000-	Member, various Study Sections
2009	Reviewer, CORE proposals, Fonds National de la Recherche Luxembourg

Honors

2008	Elected to College of Fellows, American Institute for Medical and Biological Engineering
1996	Elected Member, Omicron Kappa Upsilon Honorary Dental Society
1995-1996	National Research Service Award Senior Fellowship
1991	Elected Member, Sigma Xi Honorary Research Society
1986-1987	National Research Service Award Senior Fellowship
1983	Elected Fellow, Academy of Dental Materials .
1972-1976	Training Fellowship from N.I.H./N.I.D.R
1977-1978	Alexander von Humboldt Foundation Research Fellowship, Bonn, Germany

B. Selected peer-reviewed publications (in chronological order).

Wan, Q.; Ramsey, C.; Baran, G.: "Thermal Pretreatment of Silica Composite Filler Materials". Journal of Thermal Analysis and Calorimetry 99: 237-243, 2010.

Wang, W.; Kistler, K.A.; Sadeghipour, K.; Baran, G.R.: "Molecular Dynamics Simulation of AFM Studies of a Single Polymer Chain". Physics Letters A 372: 7007-7010, 2008.

Samuel, SP.; Li, S.; Mukherjee, I.; Guo, Y.; Patel, A.C.; Baran, G.R.; Wei, Y.: "Mechanical Properties of Experimental Dental Composites Containing a Combination of Mesoporous and Nonporous Spherical Silica as Fillers". Dental Materials 25: 296-301, 2009. PMID: 18804855.

Wang, W.; Sadeghipour, K.; Baran, G.R.: "Finite Element Analysis of the Effect of an Interphase on Toughening of a Particle-Reinforced Polymer Composite". Composites: Part A39: 956-964, 2008. PMID: 19492012.

Wan, Q.; Sheffield, J.; McCool, J.; Baran, G.R.: "Light-Curable Dental Composites Designed with Colloidal Crystal Reinforcement". Dental Materials 24: 1694-1701, 2008. PMID: 18499245.

Li, S.; Samuel, S.; Shah, A.; Hsieh, A.; Mylonakis, A.; Patel, A.; Baran, G., Wei, Y.: "Synthesis of New Organic-Inorganic Hybrids ply (HEMA-GMA-silica) and their Mechanical Properties". Journal of Materials Research 23:66-71, 2008.

Praveen, S.; Sun, Z.; Xu, J.; Ranade, R.; Patel, A.; Baran, G.; and Wei, Y.: "Compression and Aging Properties of Experimental Dental Composites Containing Mesoporous Silica as Fillers". Molecular Crystals and Liquid Crystals 448:223/[825]-231/[833], 2006.

Ranade, R.; Wunder, S.; and Baran, B.: "Toughening of Dimethacrylate Resins by Addition of Ultra High Molecular Weight Polyethylene (UHMWPE) Particles". Polymer 47:4318-4327, 2006.

Sun, C.; Saffari, P.; Ranade, R.; Sadeghipour, K.; and Baran, G.: "Finite Element Analysis of Elastic Property Bounds of a Composite with Randomly Distributed Particles". Composites A 38:80-86, 2007.

Liu, Q.; Baran, G.; Wunder, S. ; and Mante, F.: "The Role of Surface Functional Groups in Calcium Phosphate Nucleation on Titanium Foil". Biomaterials 23: 3103-3111, 2002. PMID: 12102181.

Liu, Q.; Ding, J.; Chamber, D.; Debnath, S.; Wunder, S.; and Baran, G.: "Filler-Coupling Agent-Matrix Interactions in Silica/polymethylmethacrylate Composites". Journal of Biomedical Materials Research 57:384-393, 2001. PMID: 11523033.

BIOGRAPHICAL SKETCH

Provide the following information for the key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

NAME	POSITION TITLE
Wenhai Wang	Postdoctoral Fellow
eRA COMMONS USER NAME whwang	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
Southeast University, Nanjing, China	BS	1997	Mechanical Engineering
Southeast University, Nanjing, China	MS	2000	Mechanical Engineering
Drexel University, Philadelphia PA	PhD	2007	Materials Sci. and Eng.
Temple University, Philadelphia PA	Postdoctoral Fellow	2007-	Composites design; spinal biomechanics

C. Positions and Honors

Positions and Employment

2011-present Post-Doctoral Fellow, Shriners Hospital for Children &Temple University, Philadelphia PA, USA

2007-2011 Post-Doctoral Fellow, Center for Bioengineering and Biomaterials, Temple University College of Engineering

2009- Adjunct Faculty, College of Engineering, Temple University

Other Experience and Professional Memberships

2006- Member, The Minerals, Metals, and Materials Society (TMS)

Honors

2006 NSF DMI Grantees Conference Travel Grant

D. Selected peer-reviewed publications (in chronological order).

- Wang W, Zhang H, Sadeghipour K, Baran G. Effect of posterolateral disc replacement on kinematics and stress distribution in the lumbar spine: A finite element study. Medical Engineering & Physics. 2013;35:357-64.
- Cahill PJ, Wang W, Asghar J, Booker R, Betz RR, Ramsey C, et al. The Use of a Transition Rod May Prevent Proximal Junctional Kyphosis in the Thoracic Spine After Scoliosis Surgery A Finite Element Analysis. Spine. 2012;37:E687-E95.
- W. Wang, K.A. Kistler, K. Sadeghipour and G. Baran, “Molecular dynamics simulation of AFM studies of a single polymer chain”, Physics Letters A, 2008; 372 (47): 7007-7010
- W. Wang, K. Sadeghipour and G. Baran. “Finite element analysis of the effect of an interphase on toughening of a particle-reinforced polymer composite”, Composites Part A: Applied Science and Manufacturing 2008;39 (6):956-964
- W. Wang, G. Baran, H. Garg, R.R. Betz, M. Moumene and P. J. Cahill, “The Influence of Infiltrated Cement Volume and Morphology on Retention of Pedicle Screws: A Finite Element Study”, ORS 59th Annual Meeting, San Antonio, Texas, January 26-29, 2013
- W. Wang, " Application of Finite Element Method – From Intervertebral Disc Replacement to

Spine Biomechanics", invited presentation, Polytechnique, Montreal, Canada 2012.09

- P. J. Cahill, A. Samdani, W. Wang, J. Asghar and G. Baran, "The role of the interspinous and supraspinous ligaments in preventing proximal junctional kyphosis", 17th IMAST international meeting on advanced spine techniques, Toronto, Canada, July 21-24,2010, and at the 45th Annual Meeting and Combined Course of the Scoliosis Research Society, Kyoto, Japan, September 21-24, 2010.
- A. Shilabin, W. Wang, Y. Lei, K. Sadeghipour, G. Baran and S. Sieburth, "Design of composites with nacre protein analogue interphases", COST strategic workshop on bio-inspired materials, Vienna, Austria April 13-15, 2010
- R.Balderston, A.M.Muzumdar, P. Mcafee, W. Wang, N. Anand, G. Baran, H. Zhang, N. Khanna, D. Tyndall, G. Deol and S. Khalil," Effect of posterolateral disc replacement on kinematics and stress distribution in the lumbar spine: a finite element investigation", ORS 56th Annual Meeting, New Orleans, Louisiana, March 6-9,2010
- R. Balderston, A. V. Ingalhalikar, M. Harper, A. Muzumdar, W. Wang, S. Khalil, N. Anand and G. Baran, “Does an indication based posterolateral approach to disc arthroplasty affect subsidence in the lumbar spine: an in vitro and finite element investigation”, Ninth annual global symposium on motion preservation technology, London,England April 28 - May 1, 2009
- R. Balderston, A. V. Ingalhalikar, M. Harper, A. Muzumdar, W. Wang, S. Khalil, N. Anand and G. Baran, “Spinal loading and subsidence characteristics of a lumbar posterolateral disc arthroplasty System: an in vitro and finite element investigation”, ORS 55th Annual Meeting, Las Vegas, Nevada, February 22-25,2009
- P. J. Cahill, J. Asghar, M. Harper, W. Wang and G. Baran, "Sectioning of the Intraspinous and Supraspinous Ligaments May Lead To Proximal Junctional Kyphosis: A Finite Element Analysis", 2008 CSRS Annual Meeting, Austin, Texas December 4-6, 2008; and at the ORS 55th Annual Meeting, Las Vegas, Nevada, February 22-25,2009
- W. Wang and A. Zavaliangos, “Particle decohesion during unloading and its effect on strength and anisotropy of compacts”, Proceedings of the 2007 International Conference On Powder Metallurgy & Particulate Materials, Denver, CO, May 14-16, 2007
- W. Wang and A. Zavaliangos, “FE Simulation of Die Compaction of Cylindrical Sample and Subsequent Diametrical Compression Test”, Proceedings of the 2006 International Conference On Powder Metallurgy & Particulate Materials, San Diego, California, June 18-21, 2006
- E. Hoffman, M. Barsoum, W. Wang, R. Doherty and A. Zavaliangos, “On the Spontaneous Growth of Soft Metallic Whiskers”, IEEE Holm conference, Chicago , September 26-28 2005
- W. Wang, J. C. Cunningham and A. Zavaliangos, "The Effect of Side Constraint in Rolling Compaction of Powder", 2003 International Conference on Powder Metallurgy & Particulate Materials, Las Vegas, Nevada, June 8-12,2003