



2017 AAM Fellow Nomination

Suvranu De

Citation: For his contributions to multiscale modeling of materials and soft tissue biomechanics

First Nominator: Jacob Fish

Email: fishj@columbia.edu

Signature:



Second Nominator: Subrata Mukherjee

Email: sm85@cornell.edu

Confirm: Yes

Signature:



1. Name and business contact information of the nominee

Suvranu De

J Erik Jonsson '22 Distinguished Professor of Engineering

Head, Department of Mechanical, Aerospace, & Nuclear Engineering

Director, Center for Modeling Simulation and Imaging in Medicine (CeMSIM)

JEC 2049, 110 8th St, Rensselaer Polytechnic Institute, Troy, NY 12180, USA

Voice: 518-276-6521, Fax: 518-276-6025, E-mail: des@rpi.edu

2. Professional Preparation

Jadavpur University, India

Mechanical Engineering

B.M.E.

1993

Indian Institute of Science, India

Mechanical Engineering

M.E.

1995

Massachusetts Institute of Technology

Mechanical Engineering

Sc. D.

2001

3. Appointments

2016 – Present

Professor of Surgery, University of Texas Southwestern Research Center (courtesy appt)

2015 – Present

J Erik Jonsson '22 Distinguished Professor of Engineering, RPI

2012 – Present

Head, Dept of Mechanical, Aerospace & Nuclear Engineering, RPI

2011 – Present

Professor, Dept of Mechanical, Aerospace & Nuclear Engineering, Department of Biomedical Engineering, Information Technology & Web Science, RPI

2010 – Present

Director, Center for Modeling, Simulation & Imaging in Medicine (CeMSIM), RPI

2010 – 2010

Visiting Associate Professor, Harvard University, Boston, MA

2007 – 2011

Associate Professor, Department of Mechanical, Aerospace & Nuclear Engineering, Department of Biomedical Engineering, Information Technology and Web Science, RPI

2002 – 2007

Assistant Professor, Department of Mechanical, Aerospace & Nuclear Engineering, RPI

2001 – 2001

Research Scientist, Department of Mechanical Engineering, MIT

4. Awards and Honors

Fellow, United States Association for Computational Mechanics (IACM), 2017, *Fellow*, International Association for Computational Mechanics (IACM), 2016; *Fellow*, American Institute for Medical and Biological Engineering (AIMBE), 2016; J. Erik Jonsson '22 Distinguished Professorship, 2015; Rensselaer School of Engineering Outstanding Team Award, 2012; *Senior* Member, IEEE, 2011; James M. Tien '66 Early Career Award for Faculty, 2009; Rensselaer School of Engineering Excellence in Research Award, 2008; Office of Naval Research (ONR) Young Investigator Award, 2005.

5. Significant Professional Contributions

Dr. De has made several seminal contributions to the fields of computational and applied mechanics- specifically in **muscle materials modeling** and **soft tissue biomechanics**. In the area of multiscale materials modeling, his research centers around high strain rate modeling of energetic molecular crystals and radiation damage. Some highlights of this research include:

- Shown that besides the plastic deformation mechanisms such as pressure dependent nucleation of stacking fault tetrahedra and nano-twins in shock front and their interactions with mobile dislocations, crystalline slip activity, which is a function of crystal orientation, has a significant effect on the shock response of energetic materials (EM) and the elastic-plastic shock wave characteristics in a single crystal.
- Developed continuum level nonlinear thermomechanical models for energetic molecular polycrystals under shock loading based on a novel Jacobian-free Multiscale Method (JFMM) which obviates the computation of the tangent matrix by employing Krylov subspace iterations.
- Developed a novel QM-MD-SPH computational technique that couples quantum mechanical simulations with molecular dynamics and SPH computations for the simulation of complex heterogeneous multicomponent reactive systems.
- Demonstrated the role of α - γ phase transformation of RDX on its thermomechanical response.
- Developed a defect and dislocation evolution based fully anisotropic single crystal plasticity model which can predict experimentally observed radiation hardening of FCC metals including yield drop with increase in dose and reduction of stress offset with increased loading. Successfully modeled experimentally observed anomalous radiation softening of BCC metals at low doses and intermediate temperatures ($0.05 \leq T/T_m \leq 0.2$).

In the field of soft tissue biomechanics, he has developed multiscale and multiphysics algorithms for accurate determination of soft tissue response based on *ex vivo* and *in vivo* experimental studies. Based upon these advances he is developing real time computational algorithms that have enabled the fields of surgical simulation and pre-operative planning. Some highlights of this research include:

- Developed ultrasound-based elastography technique for accurate measurement and modeling of layer-specific material properties of multi-layer hollow organs. Elucidated roles of pre-stress and nonlinear anisotropic response in these tissues.
- Developed multi-physics models of electrosurgical procedures based on infrared thermometry. Developed level set evolution equation based on Second Law of Thermodynamics to model thermal damage.
- Developed multiscale model of ultrasonically activated soft tissues with equation of state derived from a micromechanical model.

- Developed real time simulation techniques based on meshfree methods (e.g., point associated finite field) to enable simulation of complex surgical procedures involving large deformations and topological changes.
- Developed full-cycle breathing model of patient-specific human lungs based on 4D CT data to enable radiation treatment planning of lung cancer.

6. Publications

Dr. De has authored or co-authored **2 books** (co-edited), **13 book chapters**, **135 archival journal papers** and more than 214 papers in conference proceedings. His papers have received over **4,100 citations** and his **h-index is 31** (Google scholar). *Ten selected publications are listed below:*

- (1) [book] De, S., Hwang, W., and Kuhl, E. (Eds.). (2015). *Multiscale Modeling in Biomechanics and Mechanobiology*. Springer.
- (2) [book] De, S., Guilak, F., and Mofrad, M. R. (Eds.). (2010). *Computational Modeling in Biomechanics*. Springer.
- (3) Rahul, De, S. (2017). "A multi-physics model for ultrasonically activated soft tissue", *Computer Methods in Applied Mechanics and Engineering*. 314, 71-84.
- (4) Rahul, and De, S. (2017). A phase-field model for shock-induced α - γ phase transition of RDX. *International Journal of Plasticity*, 88, 140-158.
- (5) Karaki, W., Akyildiz, A., De, S., and Borca-Tasciuc, D. A. (2017). Energy dissipation in *ex vivo* porcine liver during electrosurgery. *IEEE Transactions on Biomedical Engineering*, 64(6), 1211-1217.
- (6) Dargar, S., Akyildiz, A., and De, S. (2017). *In situ* mechanical characterization of multilayer soft tissue using ultrasound imaging. *IEEE Transactions on Biomedical Engineering*. DOI: 10.1109/TBME.2016.2644651
- (7) De, S., Zamiri, A. R., and Rahul (2014). A fully anisotropic single crystal model for high strain rate loading conditions with an application to α -RDX. *Journal of the Mechanics and Physics of Solids*, 64, 287-301.
- (8) Wang, G., Peng, Q., Liu, G. R., and De, S. (2015). Microscopic study of equation of state of β -HMX using reactive molecular dynamics simulations. *RSC Advances*, 5(69), 55892–55900.
- (9) Rahul, and De, S. (2014). Multiscale modeling of irradiated polycrystalline FCC metals. *International Journal of Solids and Structures*, 51(23), 3919-3930.
- (10) Krishna, S., and De, S. (2011). A temperature and rate-dependent micromechanical model of molybdenum under neutron irradiation. *Mechanics of Materials*, 43(2), 99-110.

7. Society Memberships

American Academy of Mechanics (AAM); Association for Surgical Education (ASE), Engineering Mechanics Institute (EMI); American Institute for Medical and Biological Engineering (AIMBE); American Society of Mechanical Engineers (ASME); ASEE; AAAS; International Association for Computational Mechanics (IACM); Institute of Electrical and Electronics Engineers (IEEE); Society of American Gastrointestinal and Endoscopic Surgeons (SAGES); United States Association for Computational Mechanics (USACM)

8. Other (selected) Professional Activities:

Dr. De currently serves on the **editorial boards** of the *Journal of Computational Surgery*, *International Journal of Modern Mechanics*, *International Journal of Computational Methods*, and *Computers & Structures* as well as scientific committees of numerous national and international conferences. He served as **guest editor** of a special issue on Meshfree Methods in *Computers & Structures* in 2005, and two special issues on Computational Bioengineering, one in *CMAME* in 2006 and the other in *Engineering with Computers* in 2008. He served as chair of the *USACM Committee on Computational Bioengineering (2002-2015)* and organized or co-organized numerous symposia and mini-symposia including sessions at the USACM and WCCM. He served as general chair of the *USACM Thematic Conference on Multiscale Modeling and Validation in Biology and Medicine (MMVMB)* in San Francisco in 2012 and has served as co-chair of the inaugural *ECCOMAS Thematic Conference on Multiscale Problems in Biomechanics and Mechanobiology (MultiBioMe)* in Vienna, Austria in 2017. He is co-chair of both the *14th US National Congress on Computational Mechanics* (2017) and the *13th World Congress on Computational Mechanics* (2018). He also serves as Vice Chair (awards) of the IEEE Technical Committee on Haptics and leads/co-leads several committees of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). He has served 5 years on the Biotechnology and Surgical Sciences (BTSS) study section of the NIH as charter member and as lead of the Theoretical and Computational Workgroup of the Multiscale Modeling Consortium of the NIH. He is on the advisory board of the Mechanical Engineering department of Rose-Hulman Institute of Technology.