

Ushasi Roy

Assistant Professor, Department of Mechanical Engineering, IIT Kanpur,
201B Northern Lab -I, Kanpur, Uttar Pradesh 208016 • +91 7044090727 • ushasiroy@iitk.ac.in

Georgia Institute of Technology , Atlanta, USA

Aug 2015-Dec 2019

PhD in Mechanical Engineering

CGPA: 4/4

Minor in Materials Science

Supervisor: Dr. Min Zhou

Dissertation: Microstructure sensitive multiscale modelling of fracture in polycrystalline metals

IIT Kharagpur, Kharagpur, India

July 2011-June 2013

Masters in Metallurgical and Materials Engineering

CGPA: 9.53/10

Supervisors: Prof. K. K. Ray and Prof. U. Glatzel (University of Bayreuth, Germany)

Thesis: Fracture toughness of $\text{Al}_{23}\text{Co}_{15}\text{Cr}_{23}\text{Cu}_8\text{Fe}_{15}\text{Ni}_{16}$ and $\text{Al}_8\text{Co}_{17}\text{Cr}_{17}\text{Cu}_8\text{Fe}_{17}\text{Ni}_{33}$ high entropy alloys

Jadavpur University, Kolkata, India

July 2007- May 2011

Bachelors in Metallurgical Engineering

CGPA: 8.09/10

Supervisor: Prof. S. Mukherjee

Thesis: Grain refinement and metastable phase formation through rapid solidification of molten metals and alloys

Publications

- **U Roy**, N A Fleck, V S Deshpande, “An assessment of a mechanism for void growth in Li anodes”, **Extreme Mechanics Letters**, Vol. 46, (2021), 101307.
- **U Roy**, D L McDowell, and M Zhou, “Effect of texture on ductile fracture of polycrystalline metals”, **Journal of the Mechanics and Physics of Solids**, Vol. 151, (2021), 104384.
- **U Roy** and M Zhou, “A multiscale computational framework for predicting the fracture toughness of metals as function of microstructure”, **Journal of Mechanics and Physics of Solids**, Vol. 142, (2020), 103955.
- **U Roy**, S Kim, C Miller, Y Horie, M Zhou, “Computational study of ignition behavior and hotspot dynamics of a potential class of aluminized explosives”, **Modelling and**

Simulation in Materials Science and Engineering, Vol. 26, Issue 8 (2018), pp. 085004-32.

- **U Roy**, H Roy, H Daoud, U Glatzel, K K Ray, “Fracture toughness and fracture micromechanism in a cast AlCoCrCuFeNi high entropy alloy system”, **Materials Letters**, Vol. 132 (2014), pp. 186-189.
- Y Wei, R Ranjan, **U Roy**, J H Shin, S Menon, M Zhou, “Integrated Lagrangian and Eulerian 3D microstructure-explicit simulations for predicting macroscopic probabilistic SDT thresholds of energetic materials”, **Computational Mechanics**, Vol. 64, Issue 2 (2019), pp. 547-561.
- **U Roy**, C Ghosh, “Residual stress analysis in galvanized coating”, **Ironmaking & Steelmaking**, Vol. 43, Issue 6 (2016), pp. 465-472.
- K K Ray, **U Roy**, A Ray, M Kumari, and A Nath, Underlying deformation mechanisms for the fracture behaviour of BCC and FCC high entropy alloys, **Theoretical and Applied Fracture Mechanics**, Vol. 113 (2021), pp. 102948..
- K K Ray, V P R Chegondi, **U Roy**, R N Jha, “Search for rapid quality control of Ni-Cr-Mo low alloy steels using multifaceted approaches for fracture toughness estimation”, **Advanced Materials Research**, Vol. 939 (2014), pp. 130-137.
- R Sarkar, **U Roy** and D Ghosh, “A model for dissolution of lime in steelmaking slags”, **Metallurgical and Materials Transactions B**, Vol.47 (2016), No.4, pp. 2651-2665
- A Ray, **U Roy**, M Kumari, and K K Ray, “The role of substructural features on the deformation and fracture behavior of BCC and FCC high entropy alloys”, **Structural Integrity Procedia**, Vol. 23 (2019), pp. 299-304.

Submitted article and manuscript in preparation:

- **U Roy** and M Zhou, Grain size effects on fracture toughness of polycrystalline metals: a 2.5D model, manuscript under review in **Computational Materials Science**.

Patent

“Gripping Arrangement for an In-Situ Deformation Stage”; Application number 622/KOL/2015 dt. 02.06.15; Patent Assignee: TATA STEEL LTD; Inventor(s): C Ghosh, **U Roy**, S Das, M Dutta, D Prusty. (Published)

Conference Participation

- **25th International Congress of Theoretical and Applied Mechanics (ICTAM 2020+1), Milan (Italy)**
 - “Correlating fracture toughness of ductile polycrystalline metal with microstructure attributes” (id: 107201) has been accepted for an oral presentation. [Postponed to 2021 due to COVID-19]
- **Materials Science and Technology (MS&T) Conference, Oregon (USA)** [September 2019]
 - Oral presentation on ‘Correlating macro-scale fracture behavior with microstructural attributes in polycrystalline metals’.

- **International Conference on Materials Structure and Micromechanics of Fracture, Brno (Czech Republic)** [June, 2019]
 - Oral presentation on ‘The role of substructural features on the deformation and fracture behavior of BCC and FCC high entropy alloys’.
- **National Metallurgists Day and Annual Technical Meeting (NMD ATM)** [November 2013]
 - Oral presentation on ‘Fracture Toughness of $\text{Al}_{23}\text{Co}_{15}\text{Cr}_{23}\text{Cu}_8\text{Fe}_{15}\text{Ni}_{16}$ and $\text{Al}_8\text{Co}_{17}\text{Cr}_{17}\text{Cu}_8\text{Fe}_{17}\text{Ni}_{33}$ High Entropy Alloys’.
- **National Metallurgists Day and Annual Technical Meeting (NMD ATM)** [November 2012]
 - Poster presentation on ‘Fracture Toughness Of High Entropy Alloys’
- **National Conference on Processing and Characterization of Materials** [December 2012]
 - Oral presentation on ‘Crack Initiation Resistance of Bcc and Fcc High Entropy Alloys’

Research Experience

- **Research Associate** [Jan 2020 onwards]
Department of Engineering, University of Cambridge
 - **Investigation of void growth in solid state Li-ion batteries**
 - Development of electro-chemo-mechanical models to study void growth in creeping solids
- **Graduate Research Assistant** [Aug 2015-Dec 2019]
Woodruff School of Mechanical Engineering, Georgia Institute of Technology

PhD Dissertation

- **Microstructure sensitive multiscale modelling of fracture in polycrystalline metals**
 - My thesis work focused on modelling microstructure-explicit fracture in ductile polycrystalline materials.
 - A cohesive finite element based (CFEM) multiscale framework that takes into account the effect of grain boundary characteristics on fracture was developed.
 - The model captured the competition between deformation and fracture, and also the competition between intergranular and transgranular ductile crack propagation.
 - The model used statistically equivalent microstructure sample sets (SEMSS) to account for the stochasticity and this facilitates further probabilistic analyses.
 - Fracture resistance at the macro-scale was correlated with the microscale grain and grain boundary behavior and the microstructural attributes.
 - Crystal plasticity was introduced into the CFEM framework in order to study the effect of texture on fracture.
 - Finally the complete framework coupled with post-computation probabilistic analyses facilitated designing optimum microstructures for maximized fracture resistance.

Other projects

- **Hotspot dynamics of energetic materials**
 - A novel class of energetic materials consisting of energetic particles (HMX) embedded in a metal matrix (Al alloys) was conceived.
 - The ignition initiation and hotspot dynamics of this hypothetical energetic composite was analyzed using a Lagrangian cohesive finite element framework coupled with probabilistic analyses of post-computation results.
 - The results indicated that replacing polymer with a metallic matrix considerably reduces the sensitivity for ignition and thus could potentially be used as a safer energetic material.

- **Integrating Lagrangian and Eulerian framework for 3D simulations of energetic materials**
 - This approach combined Lagrangian and Eulerian modeling frameworks to simulate the coupled mechanical-thermal-chemical-transport processes in 3D heterogeneous material microstructure.
 - All the Lagrangian simulations were carried out by me to generate the hotspot intensity fields for Eulerian simulations that finally facilitated quantification of the probabilistic macroscopic detonation thresholds as function of microstructural attributes.

- **Implications of inherent heterogeneities and tailored structural configurations on dynamic mechanical response of additively manufactured energetic materials**
 - This ongoing collaborative project involves both experimental and computational efforts to study dynamic response of additively manufactured mock energetic materials.
 - I am involved with the 3D simulations of the microstructures and subsequent modelling of their dynamic response under impact loading, spalling, and predicting relevant X-ray Phase Contrast Images (XPCI).

- **Researcher, Tata Steel Research and development** *[July 2013-July 2015]*
 - **Origin of cracks and micromechanisms of crack propagation in Galvannealed coatings on steel sheets** (*Project Leader*)
 - **Nucleation and growth of intermetallic phases in galvanized coatings** (*Member*)

- **Masters Dissertation, IIT Kharagpur** [Jan 2012-June 2013]
 - **Dissertation Title: Fracture toughness of $\text{Al}_{23}\text{Co}_{15}\text{Cr}_{23}\text{Cu}_8\text{Fe}_{15}\text{Ni}_{16}$ and $\text{Al}_8\text{Co}_{17}\text{Cr}_{17}\text{Cu}_8\text{Fe}_{17}\text{Ni}_{33}$ high entropy alloys**
 - Microstructural characterization of the as cast alloys: Al rich alloy possessing predominantly bcc structure and Al lean alloy exhibiting matrix of fcc structure.
 - Fracture toughness of these HEAs were determined using single edge notched and chevron notched 3 point bend small volume specimens along with nano-indentation for the first time.
 - Formation of shear bands and featureless cleavage type facets were identified as the micro-mechanism of crack propagation.
 - The effect of substructural features on deformation behavior was delineated.

- **Undergraduate project, Jadavpur University** [May 2010-May 2011]
 - **Grain refinement and metastable phase formation through rapid solidification of molten metals and alloys**
 - A splat-cooling device was developed in-house to achieve rapid solidification of molten metals and alloys.
 - Extensive microstructural characterization of splat cooled Pb-Sn eutectic alloys showed formation of refined grain structure with a bimodal distribution of grain size, and nano wires of oxides.

- **Summer Intern project, NML Jamshedpur, India** [May'2010-July'2010]
 - **Evaluation of dynamic fracture toughness of 5LX-65 linepipe steel**

Teaching Experience

- **Graduate Teaching Assistant** [Aug'2019-Dec'2019]
 - **ME Systems Laboratory**
 - Demonstrate Lab classes every week for two sections.
 - Hold Q&A sessions for lab.
 - Grade reports and presentations.

- **Teaching Intern, Georgia Institute of Technology** [Jan'2017-May'2017]
 - **Mechanics of Deformable bodies (COE 3001)**
 - Prepared lecture notes and delivered seven lectures for a class of 50, consisting of undergraduate students.
 - Taken multiple review sessions with students before mid-term and end-term exams.
 - Prepared biweekly assignment problems and model solutions.
 - Held regular office hours for students.
 - Evaluated mid-term and final examination answer scripts and participated in final grading.

- **Teaching Assistant, Georgia Institute of Technology** [Jan '2018-May '2018]
 - Held regular office hours, evaluated exams and participated in final grading for the course on **Statics (C0E 2001)**
- **Teaching Assistant, IIT Kharagpur** [Jan '2012-May '2013]
 - Undergraduate course on *Mechanical properties evaluation lab* for **Spring 2012**
 - Graduate course on *Fracture Mechanics* for **Fall 2012**

Professional Membership

- Student Member, *The Minerals, Metals and Materials Society (TMS)*
- Student Member, *American Society for Metals (ASM)*

Relevant Skills

- Finite element simulations using **ABAQUS, ANSYS** coupled with post-processing using **PYTHON**
- Cohesive finite element simulations using **FORTTRAN** based in-house software **CODEX**, and **ABAQUS**
- Microstructure generation and meshing using **C++, MATLAB, DREAM3D**
- Experienced with characterization techniques like **OM, XRD, SEM, EDX**, and mechanical testing using **INSTRON UTM**

Scholastic Achievements

- Secured **third position** and awarded with **Bronze** medal in MME department of Jadavpur University in **BE**.
- Secured the **best paper** award in **NMD ATM 2013** for the *Advanced Materials* section.

References

Dr. Min Zhou, Professor, Woodruff School of Mechanical Engineering, Georgia Institute of Technology, (404) 894-3294, min.zhou@gatech.edu

Dr. David L. McDowell, Professor, Woodruff School of Mechanical Engineering, Georgia Institute of Technology, (404) 894-5128, david.mcdowell@me.gatech.edu

Dr. Vikram S. Deshpande, Professor, Department of Engineering, University of Cambridge, UK, (+44) 1223 3 32664, vsd20@cam.ac.uk

Dr. Kalyan Kumar Ray, Retired Professor, Department of Metallurgical and Materials Engineering, Indian Institute of Technology Kharagpur, (+91) 94742-30710, kalyankumarry@gmail.com

Dr. Chiradeep Ghosh, Principal Researcher, R&D Division, Tata Steel India, (+91) 80920-98321, chiradeepghosh@gmail.com