

WK6: Tribology of 2D Materials: From Nanoscale to Macroscale

Organizers: Anirudha V. Sumant and Subramanian Sankaranarayanan (CNM/ANL), Ali Erdemir (ES/ANL)

Location: Building 440, Room A105/106

The purpose of this workshop is to bring together experts from academia, national labs and industry to discuss the latest developments in the tribology of 2D materials from nano/microscale to meso-macroscale. The emphasis will be on uncovering fundamental mechanisms of wear/friction at atomic scales and finding a link to translate at the macroscale. Another aspect includes showcasing CNM's unique multifunctional tribometer to the tribology community and fostering new collaborations through the CNM user proposal mechanism.

Workshop topics:

- Superlubricity using 2D materials
- Physical/chemical interactions between 2D material layers and bulk substrates
- Theory/simulations for understanding mechanisms of sliding/shearing
- 2D materials as solid lubricants
- 2D materials as additives in composites and in liquid lubricants
- Advances in tribological properties measurements techniques
- Tribological properties of 2D materials and the mesoscopic link between nano and macro scales
- Environmental considerations

The CNM has expertise and state-of-the-art facilities in the synthesis, functionalization and characterization of 2D materials with tribological properties, with particular emphasis on understanding from nano-to-micro-to-macro scale. Applications may include new solid lubricant materials for NEMS/MEMS (nano-micro) to moving electrical contacts, sliding/rolling, rotating and bearings, etc.(meso-macro). This workshop will include topics covering fundamental studies on the development of 2D materials and their systematic characterization to understanding their structural, chemical, mechanical, and tribological properties. Also welcome are theoretical and modeling approaches that can provide in-depth understanding of tribo-physical and chemical interactions with the substrate and interfaces under severe contact pressure and shear stress; issues related to tribo-chemical changes, and substrate interactions. This workshop is expected to provide an excellent platform for academics, scientists, and students to exchange ideas, foster collaborations with user facilities at Argonne and embark upon new challenges in nanoscience.

Session 1: Physical/Chemical Interactions between 2D Materials Layers (Session Chair: Anirudha Sumant)

8:50-9:00 Anirudha V. Sumant (Center for Nanoscale Materials)
Welcome and Introduction

9:00-9:30 James Batteas (Texas A&M University, College Station, TX)
Controlling Friction, Energy Dissipation, and Chemical Reactivity in 2D Nanomaterials

9:30-10:00 Graham Cross (Trinity College, Dublin, Ireland, UK)
Self-assembly of a Graphene Ribbons on a Substrate at the Micrometer Scale

10:00-10:30 Break

Session 2: Theory/Simulations Studies on Understanding Friction and Mechanics at the Interface (Session Chair: S. Sankaranarayanan)

10:30-11:00 Horacio Espinosa (Northwestern University)
Intra and Interlayer Mechanical Properties of Graphene Oxide

11:00-11:30 Izabela Szlufarska (University of Wisconsin-Madison)
Multi-scale Model of Time Dependent Friction

11:30-12:00 Srilok Srinivasan (Argonne National Laboratory)
Effect of Graphene Wrapped Nanodiamond vs Graphitized Nanodiamond on the Superlubricity (contributed talk)

12:00-1:30 Lunch

Session 3: 2D Lubricants as an Additives in Oil and in Composites (Session Chair: Diana Berman)

1:45-2:15 Jiaxing Huang (Northwestern University)
Self-dispersed Crumpled Graphene Balls in Oil for Friction and Wear Reduction

2:15-2:45 Elena Polyakova (Graphene Laboratories, Inc.)
An Update on Development of Graphene-enhanced Composite Materials

2:45-3:05 Kalyan Mutyala (Argonne National Laboratory)
Iron Nanoparticle-driven Tribochemistry Leading to the Superlubric Sliding Interfaces (contributed talk)

3:05-3:30 Break

Session 4: 2D Materials as Solid Lubricants (Session Chair: Ali Erdemir)

3:30 Subramanian Sankaranarayanan (Argonne National Laboratory)
Machine Learnt Models for 2-D Materials and Their Tribological Applications

4:00 Diana Berman (University of North, Denton, TX)

Mechanisms for Controlling Friction and New Approaches for Achieving Superlubricity Regime in 2D Materials

4:30

Ali Erdemir (Argonne National Laboratory)
Wrap-up and closing remarks

Optional: Tour to show multifunctional tribometer facility at CNM