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Nanoscale tribochemical reaction drive superlubricity at macro scale with 2D materials-nanoparticles ensembles

In our previous studies we have demonstrated that the new super lubricity mechanism at macroscale by combined uses of graphene mixed with nanodiamonds sliding against diamond-like carbon (DLC). In particular, we showed that super low friction regime (the coefficient of friction is 0.004) is observed when graphene patches wrap around the nano diamonds and form nanoscrolls with reduced contact area sliding against an incommensurate DLC surface. In the present study, we show that other two dimensional (2D) layered material such as molybdenum disulfide (MoS_2) is also capable of demonstrating super lubricity through unique tribochemical reaction with carbon leading to formation of onion-like carbon (OLC) at the tribological interface. We have observed that beyond some initial run-in period, the friction comes down to some un-measurable levels and maintains in that state for a very long period of time, despite the fact that introduced 2D film of MoS_2 is only a few nanometer thick. Our detailed experimental and theoretical investigations suggest that formation of OLCs is possible through tribochemical reaction with these 2D materials that could occur at the tribological contact due to high contact pressure. These OLCs behaves in a similar way described earlier in our previous studies, providing reduced contact area and incommensurability with respect to the sliding DLC surface leading to super lubricity. We will discuss the detailed mechanism and highlight the similarities and differences with the previously demonstrated super lubricity involving graphene-nanodamond ensembles. This new discovery broadens the fundamental understanding of frictional behavior of 2D materials beyond graphene and opens a wide range of possibilities for implementing them in mechanical and tribological applications involving static, sliding, and rotating contacts.

Biography

Anirudha Sumant is a Materials Scientist working at Center for Nanoscale Materials, Argonne National leading the research on nanocarbon materials including CVD-diamond, carbon nanotube and graphene. He has more than 22 years of research experience in the synthesis, characterization and developing applications of carbon based materials. His main research interests include electronic, mechanical and tribological properties of carbon based materials, surface chemistry, micro/nano-scale tribology, and micro-nanofabrication. He is the author and co-author of more than 100 peer reviewed journal publications, two book chapters, winner of four R&D 100 awards, NASA Tech Brief Magazine Award, 2016 TechConnect National Innovation Award, has 20 patents granted, and 11 pending and given numerous invited talks. His research in diamond materials helped in the formation of several start-up companies including NCD Technologies Inc. and AKHAN Semiconductors Inc. He is a Member of MRS, STLE and AVS.

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