Materials Day

Abstract Guide

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Surface Insights: Exploring Glass, Carbon Tribology and polymers

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Abstract:

Surface analysis is critical as the surface properties of materials directly impact their performance in applications ranging from optics to mechanical systems. At the surface, interactions with the environment lead to phenomena such as friction, wear, chemical reactions, and mechanical failure, all of which are highly sensitive to minute imperfections and changes in surface chemistry. Advanced techniques are required to probe these fine-scale properties without altering the surface.

Silicate glass, known for its mechanical and chemical stability as well as optical transparency, is foundational in modern applications. However, these attributes are critically dependent on surface conditions, where even minor defects can drastically reduce its strength. Thus, understanding the surface properties of glass is fundamental to understanding the material itself.

Hydrogenated diamond-like carbon (HDLC) coating provides super-lubricity. HDLC exhibited significant friction reduction during macro- and micro-sliding but higher friction during nanoscale sliding, even after the running-in period with graphitic carbon transfer films. Raman analysis revealed reduced graphitization with decreasing contact scale, attributed to vastly different contact areas. In nano-sliding and fretting, limited transfer film retention due to the tiny contact area constrained shear-induced graphitization, elevating friction compared to macro- and micro-sliding.

Adhesion properties are governed by chemical reactivity on the topmost surface of materials. Due to the inherently structured non-centrosymmetric features of 2D interfaces, sum frequency generation (SFG) spectroscopy can provide information on the surface-exposed alkyl and hydroxyl groups and to monitor changes in their orientation and structure that affected adhesion performance. On the other hand, if the non-centrosymmetric requirement is satisfied, 3D bulk materials can also generate SFG signals. Specifically, SFG can provide orientational information on crystallites of biopolymers interspersed in amorphous matrix, which cannot be readily obtained by other characterizations.

Our multidisciplinary approach, combining spectroscopy, mechanical testing, and frictional analysis, provides a deeper understanding of glass, HDLC, and polymers.