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Advanced Image Processing as a tool to identify sub-surface structural transformations of self-lubricant coatings

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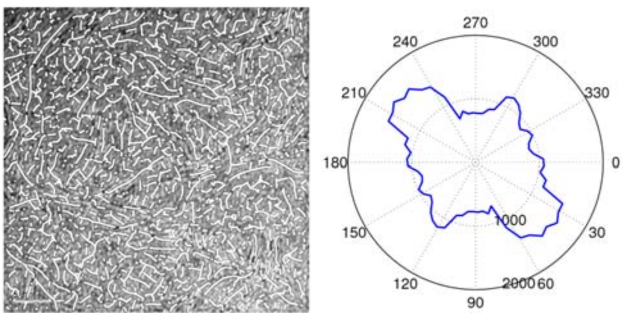
Transition metal dichalcogenides (TMD's) have attracted considerable attention due to their self-lubricant properties. TMD's exhibit low friction thanks to their anisotropic layered structure, where the adjacent lamellae with strong covalent bonding interact through relatively weak van der Waals forces. They are usually applied as solid lubricant, as oil additives or prepared as thin films to decrease friction energy losses in mechanical systems. The friction coefficient, extremely low in vacuum and to some extent in dry non-reactive gases, significantly deteriorates in the presence of air humidity. Unfortunately, this drawback together with their low load-bearing capacity, limits their use to very specific working conditions. Two solutions are being investigated in order to remedy referred drawbacks: i) development of fullerene-like and nanotube TMD material, and ii) alloying of TMD with metal or compound. The later option is usually connected with PVD processes, mainly by co-sputtering of TMD with metals or other elements. In general, alloying with other element improved their properties, such as adhesion, hardness and bearing-load capacity. Nevertheless, the high sensitivity to environmental attacks still remains the main restriction for full industrial use of TMD-based coatings as self-lubricants.

This talk is aimed mainly on the complex wear analysis of a new class of TMD's, namely molybdenym and tungsten disuphides and diselenides, alloyed with carbon prepared by magnetron sputtering. The coatings exhibit extremely low friction coefficient together with high load-bearing capacity. Special attention has been paid to the analysis of the frictional and wear mechanisms under different operating conditions. Nanoscale analysis of the wear track by sensitive surface techniques, such as Auger electron microscopy, Raman spectroscopy and high-resolution transition electron microscopy (HR-TEM), reveals the formation of a thin tribolayer (about 1-3 nm) exclusively consisted of TMD platelets parallel to coating surface. However, the most surprising feature was observed below referred tribolayer: reorientation of platelets inside amourphous carbon matrix. The main objective of this paper is to show development of Advanced Image Processing as a progressive tool for identification of a large quantity of HR-TEM images.



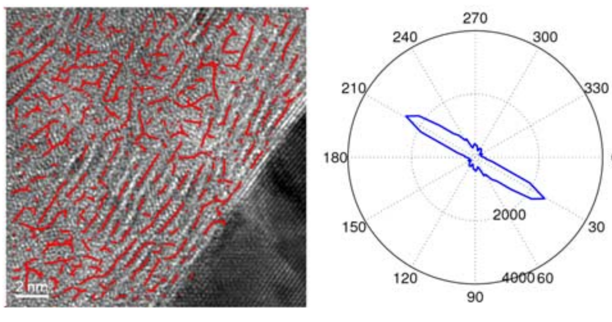


Figure 1: Image processing of HR- TEM image of as deposited MoSeC film (left) and orientation histogram showing random distribution of MoSe2 platelets in carbon matrix (right).

Figure 2: a) Hr-TEM image of MoSe2 platelets reorientation after sliding process (left) and histogram showing highly oriented structure (right).