FRICTIONAL ANISOTROPY UNDER SCRATCHING TEST FOR MOLYBDENUM THIN FILMS DEPOSITED BY GLANCING ANGLE DEPOSITION (GLAD)

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ABSTRACT
Nowadays, given the diverse range of possibilities for producing different nanostructures, thin films find applications across various technological domains such as optical industry [1], sensors [2] and solar cells [3]. Between the techniques employed for thin film fabrication, Glancing Angle Deposition (GLAD), an alternative form of physical vapor deposition, has garnered significant attention. In GLAD, the atoms from the target reach the substrate at an incidence angle (α) and numerous morphologies and structures at micro and nano-scales can be obtained [4-6]. Among these numerous options, different thermoelectric and optical properties of films with tilted nanocolumns have already been studied and, as their asymmetric geometry indicates, it is possible to observe considerable anisotropy for these properties. Although there is a lot of information on the anisotropic behavior of GLAD films in terms of their physical properties, their response under tribological or scratching conditions have been little covered in the literature. Thus, this study aims to investigate the behavior of GLAD films subjected to scratching in different directions to assess the influence of film nanostructure on mechanical response and friction, particularly exploring the possibility of anisotropy in the friction coefficient (COF). For this purpose, molybdenum GLAD films with similar thicknesses were deposited at various α angles: 0°, 30°, 40°, 50°, 60°, 70°, 80° et 85°. Scratch tests were conducted under four different normal forces (1.50 N, 2.50 N, 3.25 N and 4.00 N), varying the scratching direction (θ) from 0° to 315° with a 45° step between each condition. The COF results were then presented in polar plots and a non-linear model was employed to fit all the experimental data. Using the mathematical descriptors to characterize the anisotropy and its major axis, three distinct groups can be clearly defined: i) 0° and 30° exhibiting isotropic behavior; ii) 40° displaying non-centered symmetric anisotropy; and iii) 50°-85° with orthogonal anisotropy. The variability in the responses can be attributed to changes in morphologies, transitioning from dense and compact fibrous formations to elliptical-shaped nanocolumns, as well as to a microstructural and crystallographic evolution. Furthermore, it was verified that the applied normal force does not statistically influence the results.

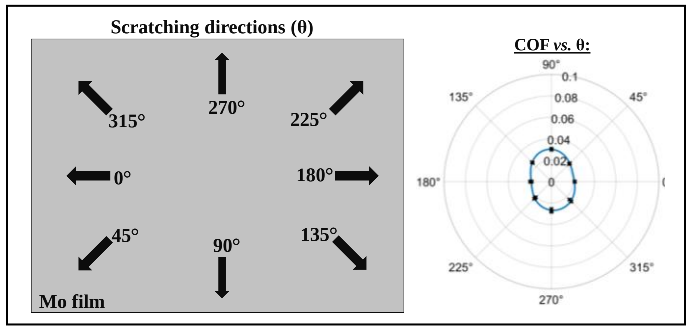

Fig.1 Scratching directions scheme and COF results for molybdenum film deposited at α 80°.

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