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UV radiation tuning friction at the nanoscale: the photo-nanotribology awakens?

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Friction is a complex phenomenon of nature that is becoming fundamental in miniaturization of moving parts. Micro/nanoelectromechanical systems and nanodevices require an accurate control of nanofriction. Our study investigates the phenomenon of friction at the nanoscale of photoactive TiO_2 thin films under the incidence of UV radiation and in the dark. UV light reduces the friction force of up to 60% and the effect is reversible (original friction force is re-established in the dark). Photosensitive materials may be used in nanosystems to tune their nanotribological properties, which may open new pathways to integrate photonics in nanotribology.

Keywords: nanotribology, nanoscale friction, UV radiation, photons

1. Introduction

Friction phenomenon is a complex manifestation of nature originated in energy dissipation events owing to the lost work of non-conservative forces. It is a property influenced by the contact area, normal force, surface chemistry, mechanical properties, presence or not of lubricants, atmospheric conditions, among others. Moreover, micro/nanoelectromechanical systems (MEMS/NEMS) are demanding nanotribology, in particular nanofriction, to tailor and optimize their properties.

Recently, the influence of radiation on the frictional behavior was reported in [1], where coumarin 6 molecules increased the friction force under the action of light in vacuum and in [2], where the frictional force in pyrene molecules was reduced under irradiation. Moreover, the photo-induced friction of TiO_2 thin films was analyzed without conclusive results in terms of friction stability under UV radiation and reversibility in the dark [3]. These seminal works are introducing a new paradigm in nanotribology, the radiation as a fourth body. The aim of the work is to show new and strong evidence of accurate control of nanofriction under irradiation and reversibility in the dark.

2. Methods

In this study, we report the friction forces at the nanoscale in TiO_2 thin films (anatase) obtained by HiPIMS as a function of the presence or absence of UV radiation (λ=365 nm and nominal power of 5 mW) by friction force microscopy (FFM). For this, the samples were measured in cycles of darkness / 3 hours of UV radiation / darkness. A normal force of 10 nN and controlled environmental conditions of temperature and relative humidity were used.

2.1. Results

According to the preliminary results, it is noted that the friction forces of thin films of TiO_2 can be tuned through the incidence of radiation. It was found that the incidence of UV radiation modifies the interactions at the sliding interface in TiO_2 thin films bringing on a dramatic reduction of frictional force of up to 60%. This reduction is strongly linked to the physical-chemical variation generated by the radiation.

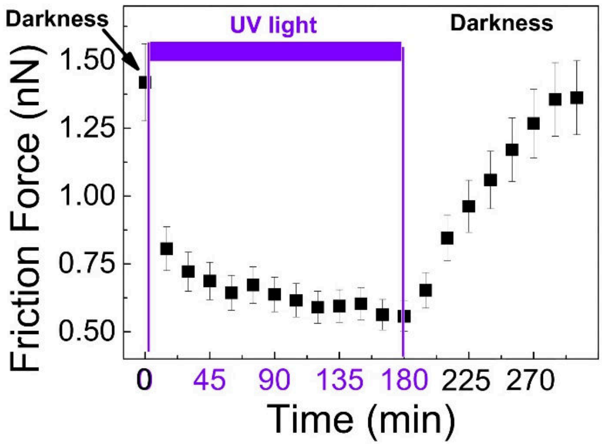

Figure 1: Photo-Frictional behavior of TiO_2 thin films.

3. Discussion

In the presence of UV radiation, TiO_2 thin films showed a frictional force reduction of up to 60%. This process modifies the dipolar moment of the Ti-O bond, resulting in the change of the frictional force of this material system in the presence of light. Under UV radiation, electron/hole pairs are created in the TiO_2 band structure modifying the surface potential, which becomes more negative and repulsive [4]. These findings may open new pathways for photo-friction tuning and the integration of photonic in nanotribology.

4. References

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