Highlights

Advanced materials and techniques for organic electronics, biomedical and sensing applications - 2018

Subnanometer resolution and enhanced friction contrast at the surface of perylene diimide PDI8-CN_2 thin films in ambient conditions

R. Buzio[1], A. Gerbi[1], M. Barra[2], F. Chiarella[2], E. Gnecco[3] and A. Cassinese[2]

[1]CNR-SPIN C.so F. M. Perrone, 24, 16152 Genova, Italy
[2]CNR-SPIN and Physics Department, University of Naples Federico II, Piazzale Tecchio, 80125 Napoli, Italy
[3]Otto Schott Institute of Materials Research, Friedrich Schiller University Jena, Löbdergraben 32, 07743 Jena, Germany

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We report high-resolution surface morphology and friction force maps of polycrystalline organic thin fi lms derived by deposition of the *n*-type perylene diimide semiconductor PDI8-CN_2. We show that the in-plane molecular arrangement into ordered, cofacial slip-stacked rows results in a largely anisotropic surface structure, with a characteristic sawtooth corrugation of a few Ångstroms wavelength and height. Load-controlled experiments reveal different types of friction contrast between the alternating sloped and stepped regions, with transitions from atomic-scale dissipative stick−slip to smooth sliding with ultralow friction within the surface unit cell. Notably, such a rich phenomenology is captured under ambient conditions. We demonstrate that friction contrast is well reproduced by numerical simulations assuming a reduced corrugation of the tip−molecule potential nearby the step edges. We propose that the side alkyl chains pack into a compact low-surface-energy overlayer, and friction modulation reflects periodic heterogeneity of chains bending properties and subsurface anchoring to the perylene cores.

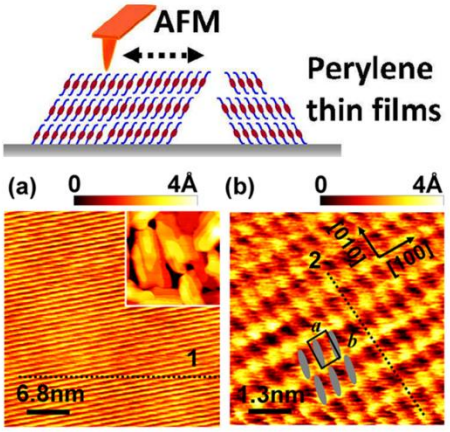

Fig.1: (a) Topography of a PDI8-CN_2 monomolecular terrace revealing an ordered, rippled surface. In the inset, a large-scale morphology (1.5 × 1.5 μm²) shows connected mesalike grains forming the polycrystalline thin film. (b) High-resolution topography of the periodic surface structure, with superimposed the anisotropic ab unit cell. Ellipses indicate the orientation of the alkyl chains predicted by a bulk structural model.

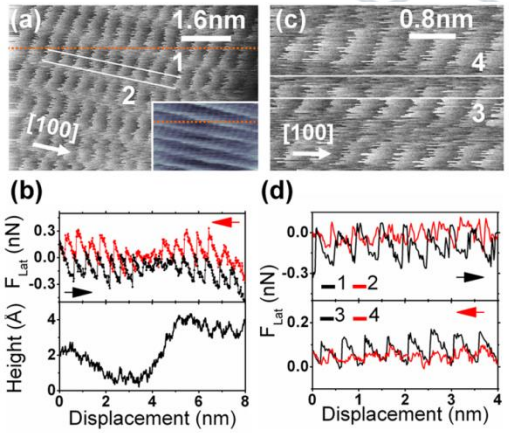

Fig.2: (a) Lateral force map over an organic domain, with the topography over the same region in the inset. Lateral force anisotropy reflects contrast variations occurring in proximity to the surface step edges. (b) Friction loop and topographic profile along the dashed line (orange) in (a). (c) A crystalline region with orientation along [100] direction (a). (d) Lateral force profiles along the [100] direction, extracted from the maps in (a) and (c), show alternation of stick − slip sliding (black curves) and superlubric sliding (red curves) within the surface unit cell.