STM investigation of ferronematic liquid crystal molecules on atomically flat Au(111) surface

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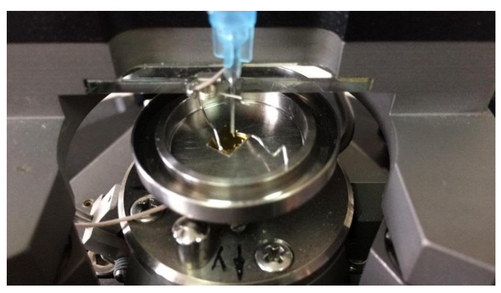
Introduction

Recently discovered ferroelectric nematic phases (N_F) are of considerable interest due to their large spontaneous polarization, which reduces the electric reorientation fields of a liquid crystal cell by a thousand times compared to conventional materials [1]. However, their application is limited because a high temperature is required for practical use. 2,3′,4′,5′-tetrafluorobiphenyl-4yl 2,6-difluoro-4-(5-propyl-1,3-dioxan-2-yl) benzoate (DIO-CN) is an extremely prospective liquid crystal material which mixing with different N_F might lower operational temperatures [2].
Here we report a STM study of the self-assembly of DIO-CN on the surface of Au(111). The absorbed DIO-CN molecules self-assemble into a monolayer film with regularly arranged molecular rows.

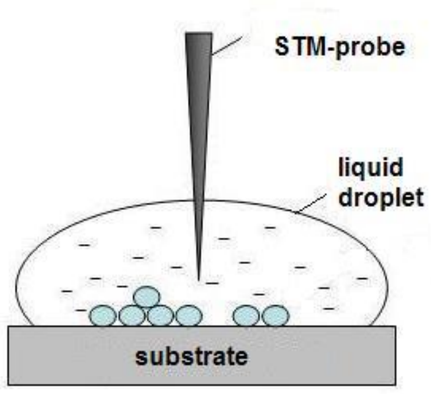
Measurement procedures

Sample-holder for STM



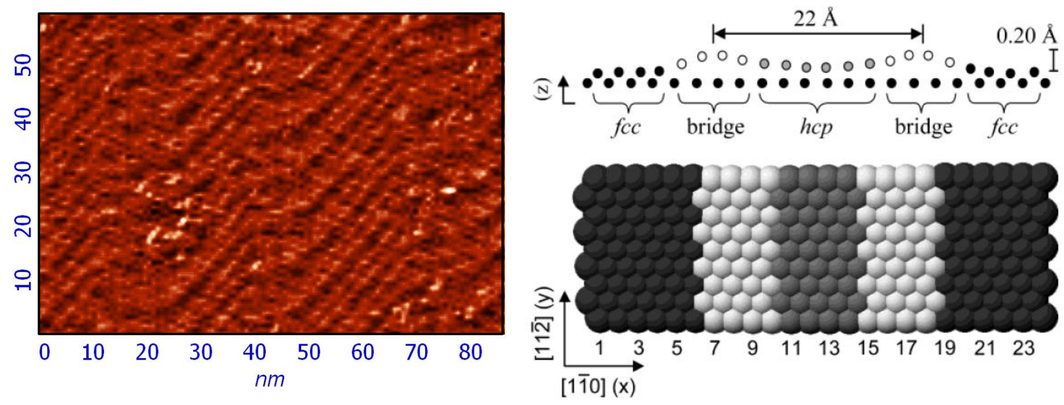
Mechanically formed Pt-Ir tip was immersed in the liquid droplet. Imaging was performed at the liquid-gold(111) interface

Liquid-solid interface



Substrate

Reconstructed Au(111) surface



Reconstructed Au(111) surface was prepared by annealing of gold substrates (PHASIS, Switzerland) in a propane-butane flame. DIO-CN was dissolved in tetradecane (99% purity, Aldrich) to a concentration of ~0.05 mg/ml. A DIO-CN solution droplet was deposited onto the Au(111) substrate. DIO-CN film was investigated in liquid-solid interface by NT-MDT Solver Pro system. The STM tips were prepared from a mechanically sharpened Pt/Ir (80:20). Typical scanning parameters correspond to a bias voltage U_t=60-600 mV and a tunnelling current I_t =40-400 pA. Several STM images in a constant-current mode are recorded with different samples and tips to verify reproducibility. STM-investigations and film preparation were performed at room temperature (~20°C).

Results

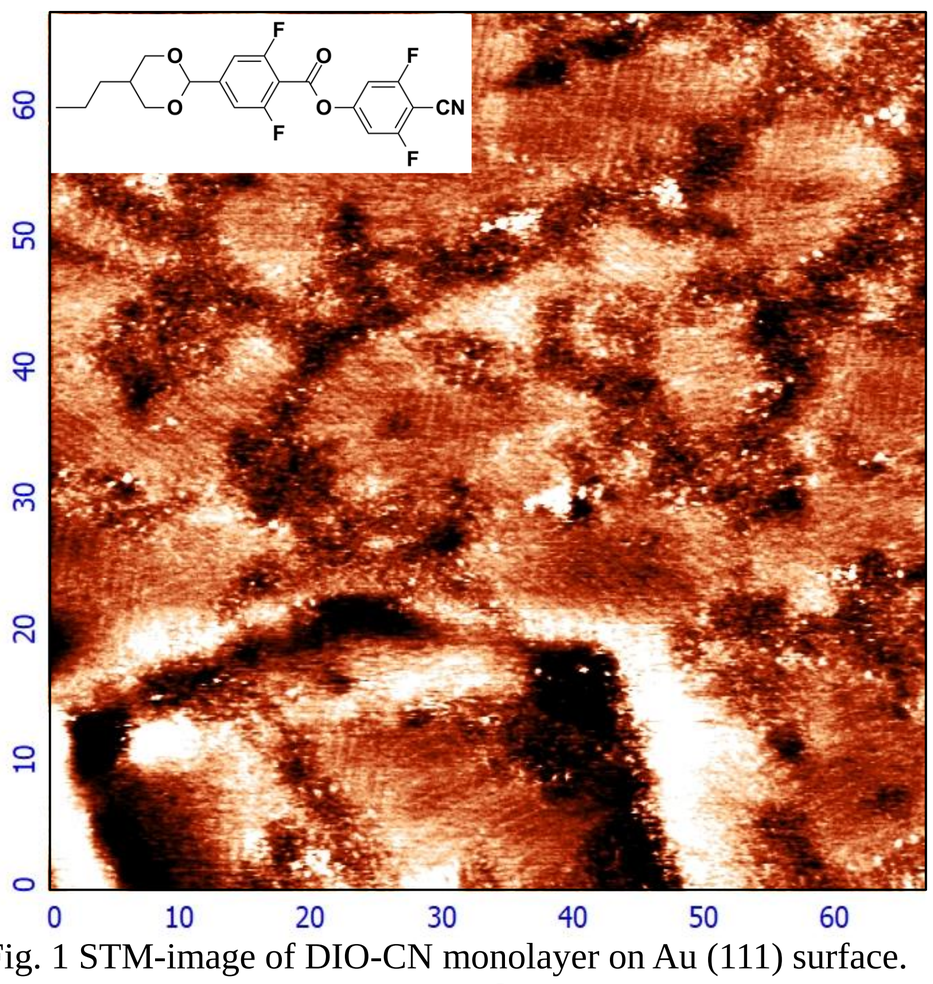


Fig. 1 STM-image of DIO-CN monolayer on Au (111) surface. Parameters of scanning: 66×66 nm^2, I_t = 40 pA, U_t = 294 mV.

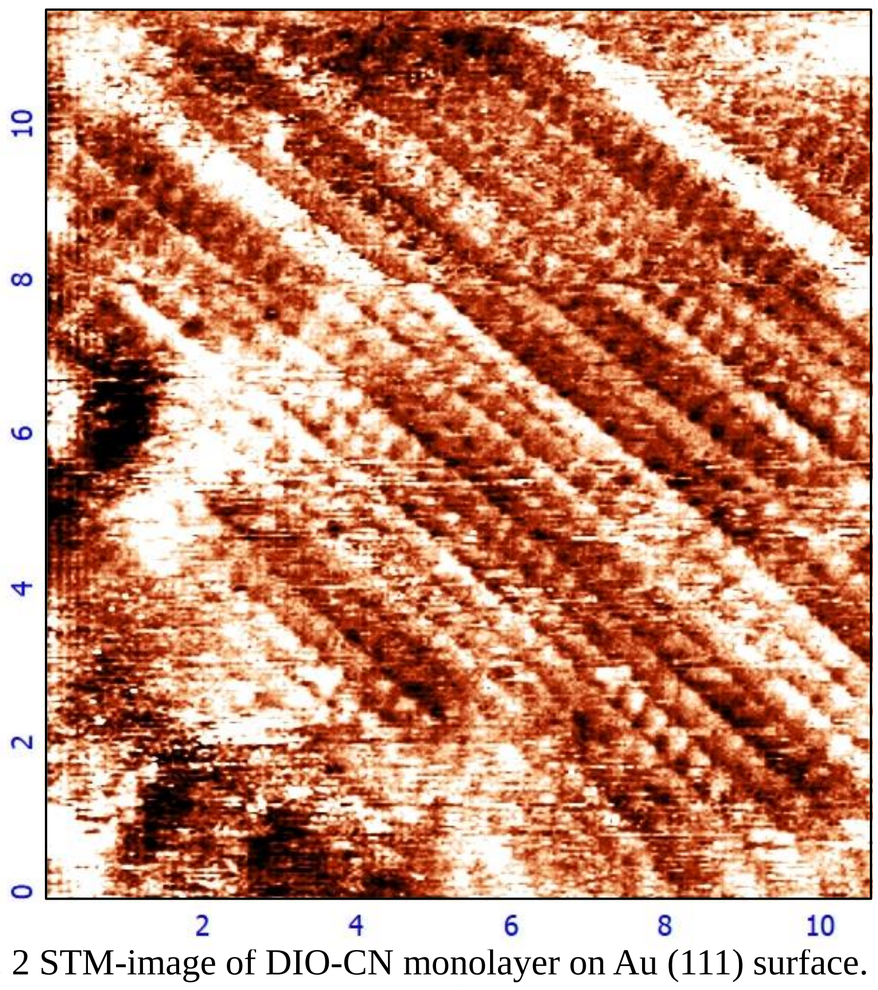


Fig. 2 STM-image of DIO-CN monolayer on Au (111) surface. Parameters of scanning: 11×11 nm^2, I_t = 107 pA, U_t = 629 mV.

Figure 1 shows a large-scale STM image of the DIO-CN molecular film adsorbed on atomically-flat Au(111) surface. DIO-CN molecules form a well-ordered domain structure. Domains consist of the same orientationally and positionally ordered parallel stripes. The orientation directions of the stripes in neighboring domains form an angle of 60º±5º or 120º±5º with each other. This indicates that the film is in strong epitaxy with the substrate. The high-resolution STM image in Fig. 2 details the polar arrangements of molecules in the layers. It is well known that conjugated π-electron systems provide a strong STM contrast, so the bright region within each molecule can be identified with its aromatic core.

1. *Chen X. et al.* First -principles experimental demonstration of ferroelectricity in a thermotropic nematic liquid crystal: Polar domains and striking electro-optics. // PNAS, 2020, 117(25), 14021-31.
2. *Nishimura S. et. al.* Lowering of electrostatic actuator driving voltage and increasing generated force using spontaneous polarization of ferroelectric nematic liquid crystals // Adv. Physics Res. 2022, 1, 2200017.