46、张向军（清华大学）——近壁面纳米液晶薄膜层的粘弹性行为与边界润滑

微纳米器件中作为润滑剂或者流动介质的液体往往受限在微纳米的间隙中，在固体壁面作用以及外场作用下变现出不同于体相的性质，如类固化、有序化排列、粘度增加、粘弹性特征等。研究采用动态石英晶体微天平测试了近壁面液晶薄膜层的粘弹性性质变化以及外电场、温度场的作用规律，揭示了近壁面纳米厚度中液晶分子独特的粘弹性变化规律，以及分子排列的变化特征；在此基础上，采用多功能摩擦试验机（UMT）实现了通过控制边界层分子排列方式来控制液晶薄膜层边界润滑特性的实验；本研究的意义在于提供了一种模型基础和技术途径，以期在微纳米器件中通过控制固体近壁面液体薄层的性质控制液体的流动以及润滑等界面行为。

47、王子千（中科院力学所）——Experimental study of Electro-elasto-capillarity: Electric field driven unwrapping of water drop with elastic film

Elasto-capillarity has drawn much of scientists' attention in the past several years. By inducing electric field into the droplet, the encapsulation and release procedure can be realized and we call it electro-elasto-capillarity (EEC). EEC offers a novel method for micro-scale actuation and self-assemble of moveable devices. It also provides a good candidate for the drug delivery at micro- or nanoscale.

In the experiment, tiny salty droplet is placed on the surface of a flexible thin (70 μm thick) polydimethylsiloxane (PDMS) film. The elasto-capillary length, L_{EC}, of the system is calculated as

$$L_{EC} = \sqrt{\frac{D}{(1+\cos\theta)\gamma}} \tag{1}$$

where D, γ and θ are the bending stiffness of the film, surface tension of the droplet and contact angle of film, respectively. For this system L_{EC} = 0.44 mm. Since the length of the film is larger than L_{EC}, the film wraps the droplet spontaneously with its surface tension (Fig. 1).

In EEC, when applied with electric field, the PDMS film tends to unwrap the drop because of the joint effect of Coulomb force, surface tension and elastic force (Fig. 2). When the voltage reaches a critical value, about 650 V in this experiment, the film is pulled-in to the substrate and release the droplet completely.

Theoretically, when the voltage reaches pull-in value, the energy of system contains elastic strain energy, surface energy and electric field energy. Due to the conservation of energy,

$$\frac{1}{2}L\frac{D}{R^2}+\frac{1}{2}C_{pre}U_e^2=\gamma L+\frac{1}{2}C_{pos}U_t^2 \tag{2}$$

where L, D, C, γ and R are the length of the film, stiffness of the film, capacitance of system, surface tension of the liquid and the radius of the drop, respectively. C_{pre} is measured to be 13 pF experimentally, since the irregular shape of the system complicates the theoretical solution. Consequently, the pull-in voltage solved from the equation is about 311 V, which is in the same order of magnitude with the experimental value.

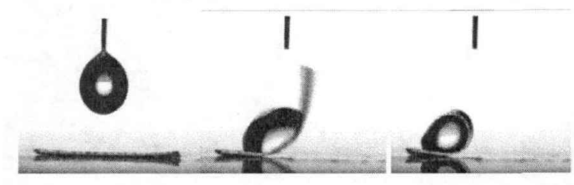

Fig. 1 PDMS film encapsulates the drop.

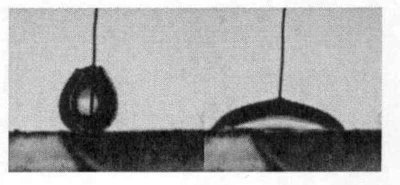

Fig. 2 Electro-elasto-capillariy

48、李喜德（清华大学）——Thermal fatigue behavior of Au interconnect lines

With dramatic reduction of the size of microelectronic devices, the characteristic width of interconnects in large-scale integrated circuits has reached 45 nm. Such small interconnects will inevitably suffer thermal fatigue damage because of temperature swings while working in circuits. In this paper, thermal fatigue behavior of Au interconnect lines with 20 m long, 35nm thick and 500nm-100nm wide was investigated by using alternating current to generate cycling temperature and strain/stress. Compared to the fatigue experiments, the fatigue mechanism in the interconnect lines was also discussed.