Sliding Friction by a Liquid Meniscus Bridge between Parallel Plates

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1. Introduction

Frictional, capillary and viscous forces are among the most influencing factors in micro and nano-mechanics. In the presence of liquid film, droplet or condensed water from humid air on a surface, a liquid meniscus bridge can be formed between two bodies. The liquid bridge causes a strong interaction heavily influences the operation of micro/nano devices.

A normal component of capillary force is widely studied. Hysteresis in a force-curve detection during approaching and retrieving process of two surfaces is mainly appeared with capillarity. In this study, we focused on the lateral component of capillary forces. A force during sheared process of a liquid bridge between parallel plates was measured. Behavior of contact lines which have an important role on the lateral component of capillary force was also observed.

2. Experiment

A liquid meniscus bridge is formed between parallel plates. The lateral force acts on the plate during sheared process is measured. And the deformation of the meniscus bridge is observed by a CCD camera through a microscope. By using image-processing technique, movements of contact line are tracked. And, change in contact angle can be calculated with an assumption that a radius of curvature is constant.

3. Result and discussion

Figure 1 shows a snapshot of a liquid meniscus bridge of 10μL water between a gap of 1mm. Asymmetrical shape appears with shear. Fig.2 shows a typical trend of lateral force and change in contact line movement and contact angle at four contact lines. Deformation of the liquid bridge with pinned contact line result in the increase of lateral force. When the lateral force reach a limit, interfacial slip with depinned contact line occurred.

To explain these trends, change in interfacial energy during shear is calculated. A derivative of interfacial energy corresponds to a force needed to shear the liquid bridge. Figure 3 shows that some additional factors are necessary to depin the contact line.

Fig. 1 Snapshot of liquid meniscus bridge between glass plates under shear, dotted edge with "TL" means position of a detected contact line at the Top – Left

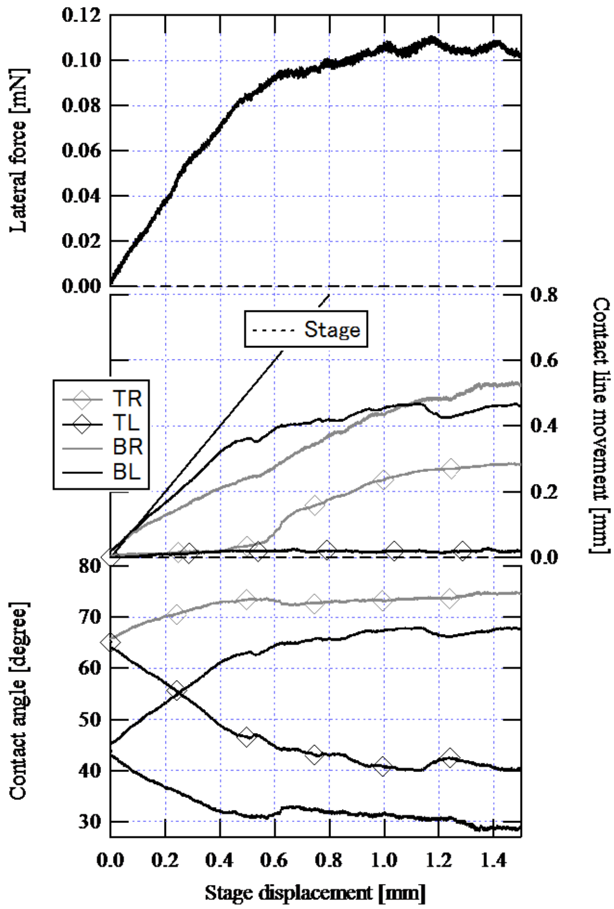

Fig. 2 Typical trend of lateral force, contact line movement and contact angle

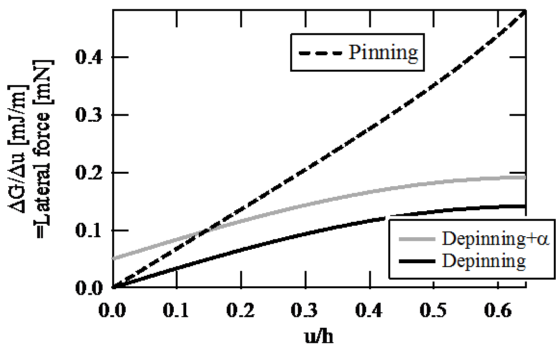

Fig. 3 Calculated lateral force with pinned and depinned contact line model