Electrohydrodynamic Analysis of L-DEP Force Driven Imprinting Process by Coupling L-DEP Theory and Two Phase Flow Method

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Imprint lithography is a low cost, high throughput patterning technique compared with traditional lithography, such as optical lithography, electro-beam lithography, and so on. However, the conventional imprint lithography with huge externally mechanical pressure suffers the drawbacks of poor uniformity, shear and rotation stress, leading to low yield and poor alignment. Based on the disadvantages of the common imprint lithography, electrostatic force-assisted imprint lithography has attracted much more attention as a novel structuring approach for fabricating micro-/nano- structures, with widely potential in biomedical fluids, optoelectronic device, sensors, and so forth. In this technique, the electric field instead of external pressure supplies the force to drive the polymer to fill into the cavities on the template to avoid the drawbacks induced by mechanical pressure.

As for the influence of electric field on dielectric material, some researchers found that the liquid dielectrophoresis (L-DEP) force acting on the gas/liquid interface drives the dielectric medium to move to the strong electric field region. For the L-DEP phenomenon, it differs from the electro-osmosis, ion drag effect, and other electrohydrodynamic (EHD) phenomenon in that it is not really a pumping mechanism. It influences the movement of dielectric material in a way analogous to the capillarity, in which it pulls the material to move upwards and is obvious in the Pellet's classic experiments. Here, the flow of the dielectric fluid consists of two parts: one is the air, and the other is deformed material. Subsequently, a method of two phase flow can be adopted to describe the movement of the fluid containing air and dielectric medium, in which the surface tension and scale effect can be introduced flexibly.

In this paper, a model combing the L-DEP theory and two phase flow method is proposed to depict the process of electrostatic force-assisted imprint lithography, in which it can be defined as L-DEP force driven imprint lithography. Firstly, the proposed model is validated by comparing the experimental structures with the numerical simulation, *see* Fig. 1. In subsequence, the detailed evolution of the process is analyzed from the distributions of electric field and velocity, accompanied with the approach to increase the aspect ratio of formed structures from the viewpoint of applied voltage, permittivity of dielectric polymer and the permittivity and thickness of dielectric layer.

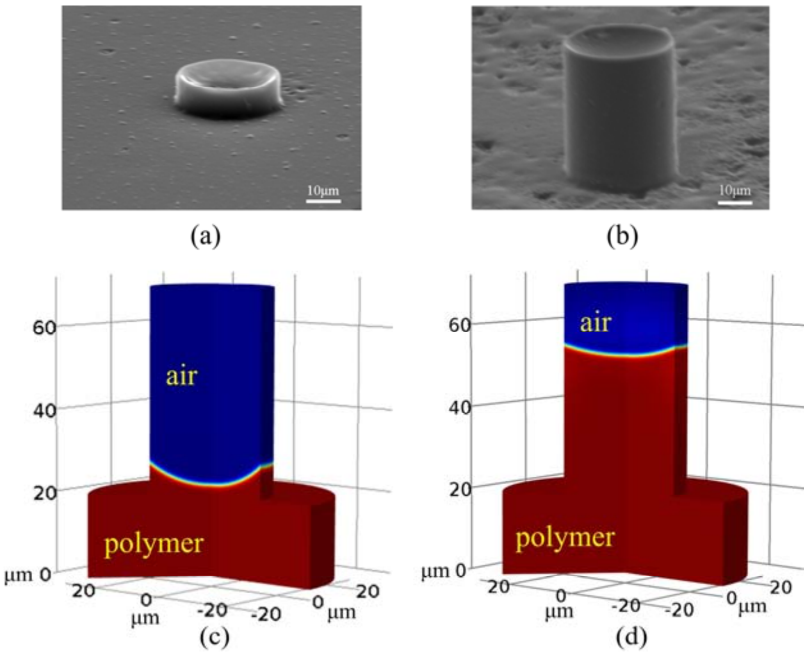

Figure 1: Comparison of the experimental results and the numerical ones: (a) duplicated cylinder by natural capillary force (*i.e.* voltage of 0V) with height of 6µm, (b) duplicated cylinder by L-DEP force (voltage of 200V) height of 40µm, (c) and (d) are the numerical results corresponding to (a) and (b), respectively