A Model of Electric Field Assisted Capillarity for the Fabrication of Hollow Microstructures

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Abstract

Electric Field Assisted Capillarity (EFAC) is a novel technique for the fabrication of hollow polymer microstructures. It has advantages over current methods as it is a single step process and so does not require expensive multiple stages. Hollow microstructures have many uses in industry from microchannels and microcapsules in BioMEMS to fibre-optical waveguides.

The technique makes use of the dielectric properties of polymers combined with a heavily wetted surface to produce fully enclosed microstructures. The dielectric force on the molten polymer under a shaped electric field causes the polymer to move upwards in the region of high electric field (Figure 1). Once this reaches the heavily wetted top mask, the surface tension pulls the polymer around to coat the top mask forming a fully enclosed channel (Figure 2) [1]. This technique is currently at an early stage and so a model has been developed in COMSOL 4.2 to look at the complex interactions of the forces involved. The model is a fully coupled model combining both the electrostatics and phase-field modules within COMSOL. The electric field is solved using the electrostatics module; a dielectric force is then fed back into the phase-field module to move the surface. As the surface move the permittivity in the domain change, this in turn feeds back into the electrostatics module altering the shape of the electric field. As this process was only discovered recently this is the first time that a model of the process has been considered. COMSOL Multiphysics was used to make the model as it was the quickest way to get a model working with the tools available. The model shares some similarities with models for electrohydrodynamic induced patterning, also known as lithographically induced self-assembly. Results from the simulations agree with the limited experimental data available and have suggested several further avenues for experimental study, most notable the wettability of the top mask which from simulations appears to have an effect on the final cap thickness.

Reference

[1] “Self-encapsulated hollow microstructures formed by electric field-assisted capillarity”, H. Chen, W. Yu, S. Cargill, , M.K. Patel, C. Bailey, C. Tonry, M. P. Y. Desmulliez, Journal of Microfluidics and Nanofluidics, 2012, doi: 10.1007/s10404-012-0942-6.

Figures used in the abstract

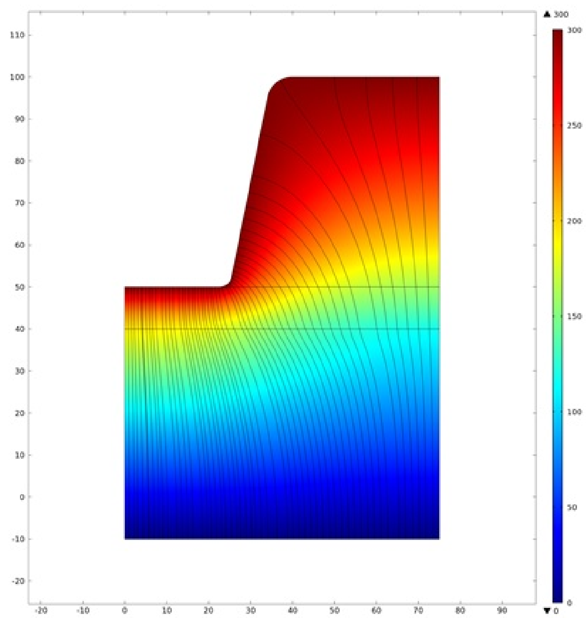

Figure 1: Electric Field (Streamlines) and Voltage (Colour) at the start of the process.

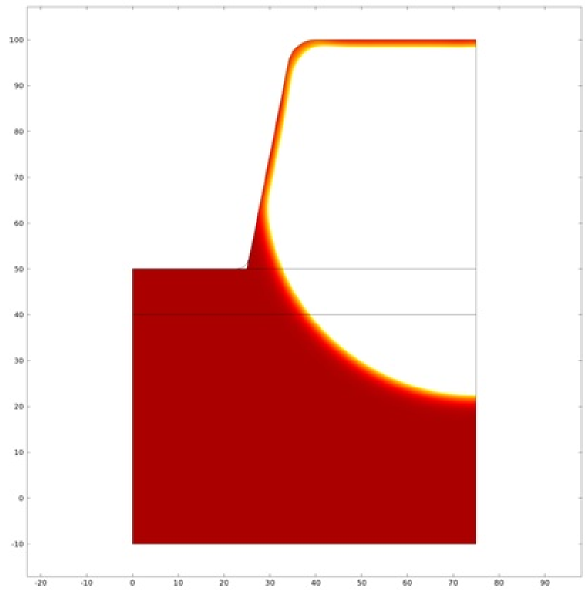

Figure 2: Free Surface plot for a completed enclosed micro channel.