Understanding Uniformity and Manufacturability in MEMS Embossing

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The hot embossing of thermoplastic materials, such as polymethylmethacrylate (PMMA) or cyclo-olefin copolymer (COC), is a promising way to manufacture microfluidic channels and networks [1]. Hot embossing potentially offers lower per-area cost than the micromachining of quartz or silicon and easier scaling-up of production than soft lithography using polydimethylsiloxane [2]. In hot embossing, a microfabricated mold (typically of silicon or nickel) is pressed into a flat sample of polymeric material that has been softened by heating it above its glass-transition temperature. We are particularly interested in how the spatial distribution of mold features—their diameters, shapes, and areal densities—may influence the quality of embossed patterns. We are developing a simulation approach whose building-block is a simple model in which, for given embossing conditions, a feature-sized disk of viscous polymer is compressed at a rate inversely proportional to the square of the radius of the disk [3] (Figure 1). Such a model implies that the mold will sink into the substrate at a spatially uniform rate when the product of the areal density of mold features and the square of their average radius remains constant across the mold. We aim to construct a reliable model that is computationally efficient and that can predict the combination of embossing pressure and duration required by any mold design. We are investigating the measurement of birefringence of embossed samples [4] as a way of monitoring the embossing process (Figure 2). We are also pursuing a technique for the bonding of polymer surfaces that promises minimal deformation of pre-embossed features: the polymer surfaces are exposed to an oxygen plasma for ~1 minute and then pressed together [5].

REFERENCES