Towards defects-free mass production of plastic microfluidic devices: fundamentals and applications

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Abstract

Polymer micro/nano replication is widely used for the mass production of plastic microfluidic devices, involving processes such as micro injection molding, micro hot embossing, and nanoimprinting. However, during replication, adhesion and friction between the polymer and the mold can easily deform or damage the replicated features during demolding. This may result in material residues remaining in the micro/nano cavities, leading to mold blockage, which requires tedious cleaning or even costly mold replacement. To address these challenges, we have developed a novel technology that co-deposits nanomaterials with nickel to create a range of innovations, including a self-lubricating nanocomposite mold and electrochemical shaping for microstructures. The nanocomposite mold not only reduces adhesion and lowers the coefficient of friction between the polymer and the mold but also significantly improves mold hardness and wear resistance, greatly extending tool life. Unlike traditional coating methods, our nanocomposite mold does not require additional coatings, thereby enhancing the dimensional accuracy of features, especially in nanoimprinting, where tolerances are defined within the nanometer range. I will also share insights into the self-lubrication mechanism of the nanocomposite mold and present a commercial case of defects-free production of microfluidic chips. We believe this technology holds great promise in overcoming demolding challenges in micro/nano replication, enabling defects-free production of polymeric microstructures for microfluidic applications.

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Dr. Nan Zhang is an Associate Professor at the School of Mechanical and Materials Engineering,

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