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Centrifuge-aided micromolding of micron- and submicron-sized patterns

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Abstract

Developed from soft lithography, replica molding has been proven to be a good method to prepare micron- and submicron-sized features. However, the fidelity of the features can be compromised by incomplete feature cavity filling and feature shrinkage during the forming process. In this study, centrifuge-aided micromolding is developed to prepare micro- and submicron-sized ZnO features. By introducing a centrifugal force, the shear-thinning behavior of the suspensions is utilized, and the cavity filling process and the diffusion of trapped air out of the features are accelerated. The drying shrinkage is decreased by increasing the density of the wet nanoparticle packing from the centrifugal process. The centrifugal force improves the fidelity of all the designed features. ZnO ridges from 0.4 µm to 2 µm size and rods of 1.6 µm size are prepared successfully. The wide applicability of this strategy has been demonstrated by preparing ZrO_2 features via the same method.

Keywords: centrifuge-aided micromolding; suspensions; ceramic patterns; micron-sized rod and ridge.

1. Introduction

Device miniaturization requires effective approaches to fabricate components with small sizes. Microfabrication of ceramics has gained considerable attention due to its great potential to meet this increasing need [1]. At the same time, soft lithography has attracted great interest in the fabrication of micro- and nano-structures since the 1990s [2]. Using soft lithography, high-quality 3D patterns can be obtained on both planar and curved surfaces, and the size range is from microns to nanometers [3-5]. To date, many kinds of soft lithography techniques have been developed, such as replica molding [6, 7], microtransfer molding [8, 9], micromolding in capillary [10], solvent-assisted micromolding [11], nanotransfer printing [12], decal transfer lithography [13], and nanoskiving [14]. Various materials have been used to prepare micro-features, such as polymers [10, 15], macromolecules [16], metals [17, 18], carbon [19], and ceramics [20, 21].

When ceramic nanoparticles are used as the starting materials for microfabrication, the low flowability and extremely loose packing of particles limit the patterning ability. Proper suspensions with high particle mobility should be created in order to accelerate the particle movement into the features and pack densely. To produce micron- and submicron-sized features from ceramic nanoparticle suspensions, two aspects should be closely examined: the filling process and the drying process. The filling

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