Fabrication of ZnO Three-Dimensional Hierarchical Nanostructures for Wicking Applications

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Wicking, the imbibition of liquid into narrow spaces in micro/nanostructures without the assistance of external forces, has drawn much attention due to its potential applications in many engineering fields. This phenomenon is controlled by the balance between the capillary force that drives liquid into small spaces and the impeding liquid viscous force [1]. Nanostructures with high surface roughness has increased the ratio of actual surface area to projected area, and can improve wicking dynamics. In recent research, wicking phenomenon in different kinds of engineered two-dimensional micro/nanostructures such as arrays of nano-pillars and nanotubes [2-4] has been studied and demonstrated excellent properties.

In this work, we focus on increasing surface roughness of nanostructures with 3D hierarchical features to obtain improved wicking dynamics. Fabrication process of the proposed structure includes three main steps, as demonstrated in Figure 1. Initially, periodic 2D nano-pillars are patterned in photoresist using interference lithography. The nano-pillars are then coated with an conformal ZnO thin film using atomic layer deposition (ALD) as a seed layer, followed by hydrothermal synthesis of ZnO nanowires [5-6]. The thickness of ZnO ALD and the length of nanowires are independently controlled by numbers of deposition cycles and the nanowire growth time, respectively. Initial fabrication results with 60 nm, 90 nm, 120 nm and 170 nm nanowire length on 500 nm period pillars are shown in Figure 2.The fabricated hierarchical 3D structures with four different lengths of nanowires are tested for water wicking properties using a high-speed camera. Initial results indicate that wicking improves with increasing nanowire length, but degrades when the length are longer compared with the pillar period. We will construct a wetting model to examine how the capillary and viscous forces are affected by the pillar and nanowire geometries.

We will present the detailed fabrication process of the proposed 3D hierarchical nanostructure and the influence of different pillar and nanowire geometry on the wicking dynamics of water in these structures. The experimental data will be compared with a fluid model based on the balance of capillary and vicious forces in these hierarchical nanostructures. We will also explore the durability of these structure in multiple wetting experiments.

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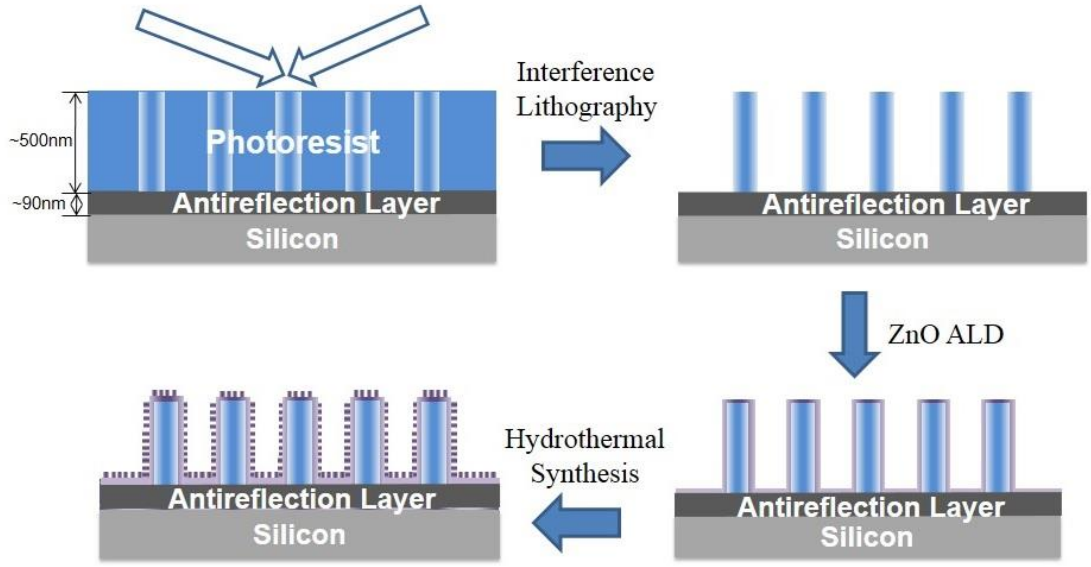
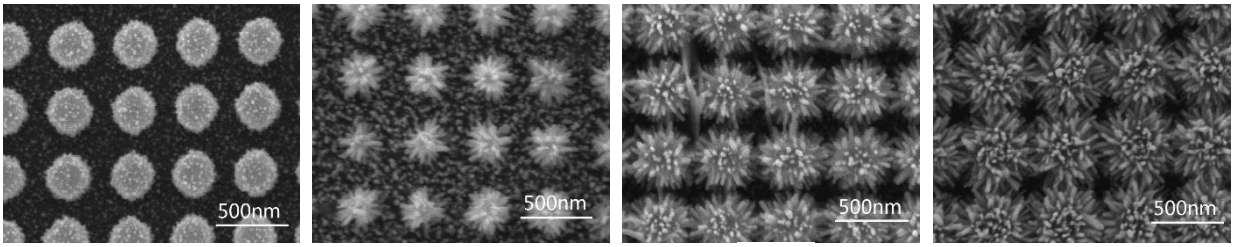


Figure 1 Fabrication of ZnO three-dimensional hierarchical nano-structures.



(a) (b) (c) (d)

Figure 2 Top-view micrograph of fabricated 3D hierarchical nanostructures with (a) 60 nm, (b) 90 nm, (c) 120 nm, and (d) 170 nm nanowires.

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