Area-Selective Atomic Layer Deposition of Zinc Sulfide Based on Inherent Selectivity

Chao Zhang, Zhongmei Han, Marko Vehkamaki*, Markku Leskelä, Mikko Ritala

Department of Chemistry, University of Helsinki, P.O. Box 55, 00014 Helsinki, Finland

The need for simplifying and improving complex electronic device fabrication has motivated the research on area-selective atomic layer deposition (ALD). Area-selective ALD is a bottom-up approach enabling deposition of thin films only on the desired surface areas, thereby accomplishing film patterning more easily as compared with conventional lithography. [1]

It is well known that ALD process involves chemical reactions between precursors and reactive sites existing on substrate surfaces.[2] So, in principle area-selective ALD can be achieved by surface modification, which include surface passivation and activation. Surface passivation means that reactive sites on the substrate surface are blocked by passivation layers, thus losing their reactivity with ALD precursors. Area-selective ALD by surface passivation has already been studied for years, focusing on using self-assembled monolayers (SAMs) and thermally stable and unreactive polymers as resist layers to prevent the film growth.[3-6] On the contrary, surface activation provides an opposite way to attain selective film growth by patterning of seed layers that can promote ALD film growth catalytically. For example, Färm et al. proved an easy way that used micro contact printed RuO_x films as a seed layer for catalyzing ruthenium ALD process[7].

Here, a new approach based on inherent selectivity of an ALD process is presented for area-selective ALD. It is found that ALD of ZnS, using elemental zinc and sulfur as precursors at a deposition temperature of 500 ^{o}C, takes place on Au surfaces but not on Si surfaces with about 2 nm native SiO_2 on top. As a reason for this selectivity, it is suggested that sulfur adsorbs much stronger on Au than on SiO_2. The continuous ZnS growth even after the Au surface is completely covered with ZnS can be similarly explained in terms of strong adsorption of sulfur on ZnS. Alternatively, the selectivity could also arise from Zn alloying with Au, this alloy then reacting with the subsequent sulfur pulse. Patterned Au structures used in our experiment consist of three different size dots (500, 250, 50 μm), prepared by electron beam evaporation (EBE) with a shadow mask. After the deposition of ZnS on this patterned surfaces, ZnS films were detected only on Au dots as confirmed by EDX measurements.

References

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