206a Preparation of Hydrophobic Multilayers on Solid Surfaces

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Modification of solid surfaces has found applications in many areas such as sensors, biocompatible coatings, microelectronic devices, thin film optics, water-resistant coatings, anti-corrosive coatings, adhesion enhancement, and nano-particle synthesis. Among the various surface modification techniques, deposition of a self-assembled monolayer (SAM) by organosilanes is very versatile, and it has demonstrated numerous benefits over others. However, SAMs sometimes demonstrated poor stability in aqueous media and silane multilayers are preferred in many applications due to their better durability. The research on the preparation of stable hydrophobic multilayers is very limited. Hydrophobic multilayers of silanes on solid surfaces were formed with the assistance of radio-frequency plasma or microwave plasma in the vapor phase in the past. There are a few drawbacks to these plasma-assisted deposition technique. (1) The chemical nature of the silane molecules was altered by the plasma; (2) the optical property of the base material could be severely impaired; and (3) the samples were subjected to a high risk of being damaged by the plasma sources.

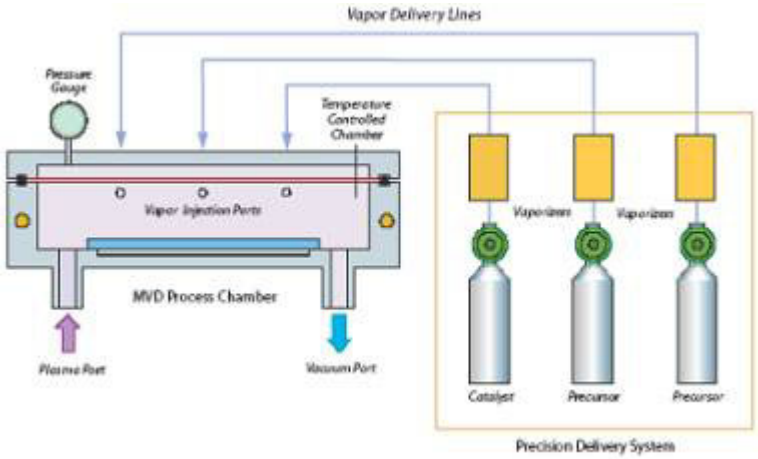

Figure 1. Schematic illustration of the MVD system used for chemical vapor deposition. Three gas lines are designated for catalyst, precursor I and precursor II.

Here we report a novel approach of preparing durable hydrophobic multilayers on solid surfaces at room temperature by molecular vapor deposition (MVD), which can generate high-quality SAMs as well. Figure 1 shows the configuration of the MVD system. SAMs were typically formed under anhydrous conditions, while multilayers were formed by sequential layer deposition or simultaneous crosslinked deposition. The thickness of the multilayer can be controlled between 5 to 70 nanometers. This technique is faster, more economical and environment-friendly than the conventional wet processing techniques, and the reproducibility and quality are better as well. In a vacuum chamber with the solid substrate inside, vapors of organosilanes, adhesive silanes, and catalyst (water) were introduced with controlled dosages, with deposition time ranging from 5 to 60 minutes. In this solvent-less process, micropatterns of SAM and multilayer could be easily obtained on the solid surfaces. Figure 2 shows the AFM images of fluoroalkyl silane (FAS) self-assembled monolayer (SAM) and multilayer on monocrystalline silicon surface. The former is very smooth at atomic level, while the latter is very rough. Although there seemed to be many defects on the multilayer surface, both SAM and multilayer showed superior stability in saline solution at 37 °C.

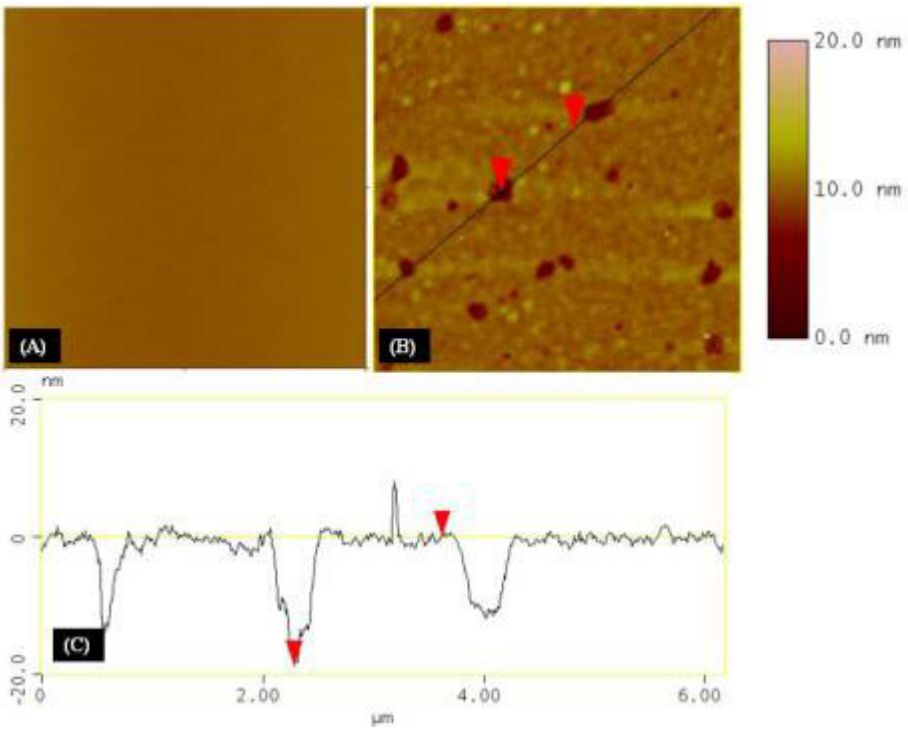

Figure 2. AFM images of (a) FAS SAM and (b) FAS multilayer on silicon (111) surface formed by MVD. The imaging areas are 5 mm x 5 mm. The thickness of FAS SAM and multilayer is 1.1 nm and ~ 20 nm, respectively. (c) is the depth profile along the line shown in (b).