

CONTROLLED CO-EVAPORATION OF SILANES FOR NANOIMPRINT STAMPS

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Nanostructured stamps used in nanoimprint lithography (NIL) are mainly made of Si wafers. They have a high surface quality (roughness, flatness) and are suitable for standard cleanroom processing. As anti-adhesive coatings for Si stamps fluorinated trichlorosilanes with different carbon chain lengths are commonly used due to their low surface energy, high surface reactivity, and high resistance against temperature and pressure. We recently found that the anti-adhesion properties for Si stamps coated with a fluorinated trichlorosilane (TFS) can further be improved by simply co-evaporating with monochlorosilanes (MFS). This is attributed to the reduced static hindrance between the silane molecules by an introduction of monochlorosilanes, resulting in a better molecular packing than that of the individual silane coatings. In order to optimize this process, however, it is necessary to develop a coating process which allows exact control over the composition between the two silanes during co-evaporation and to understand the composition dependence on the anti-adhesion properties, which we will present in this contribution.

The silane coatings were performed in the gas phase at room temperature by injecting the premixed silane into a vacuum chamber. The composition of the two silanes was controlled during the premixing. The surface is characterized by contact angle measurements, atomic/lateral force microscopy (AFM/LFM), and x-ray photoelectron spectroscopy (XPS).

Fig.1 shows water contact angles on Si surfaces coated with the mixed silanes for different amounts of total silanes injected. Both curves show non-linear behavior, indicating that a reaction between MFS and TFS is involved in addition to the reactions between the molecules and the substrate surfaces. Best results were obtained when both silanes were applied in equal quantities. This agrees very well with the silane coverage measured by XPS. On the other hand, when a fluorinated trichlorosilane with a longer carbon chain (C10) length was used, the maximum in the contact angle was achieved at a different composition. This demonstrates that the chain length and reactivity of individual silane molecules play an important role in determining the optimized composition of the silane mixture. We have performed imprint tests using flat Si stamps coated with 1:1 mixtures of MFS/TFS (Fig.2). Despite the same amount of the total silane mixture injected, a broad range of contact angles are seen initially depending on the amount of solvent used for dilution. However, as imprints continue, the distribution becomes narrower and the contact angle seems to converge at a certain value. This is attributed to a certain reorganization process occurring within the silane layer upon high temperature and pressure imposed during imprint process.

References:

- [1] S. Park, H. Schiff, C. Padeste, A. Scheybal, T. Jung, B. Schnyder, R. Kötz and J. Gobrecht, *Improved Anti-adhesive Coating for Nanoimprint Lithography by Co-evaporation of Tri- and Monochlorosilanes*, MRS2003 - Fall Meeting, Boston, MA (USA), Dec. 1-5, 2003, to be published in MRS proc. (2004).

Figures:

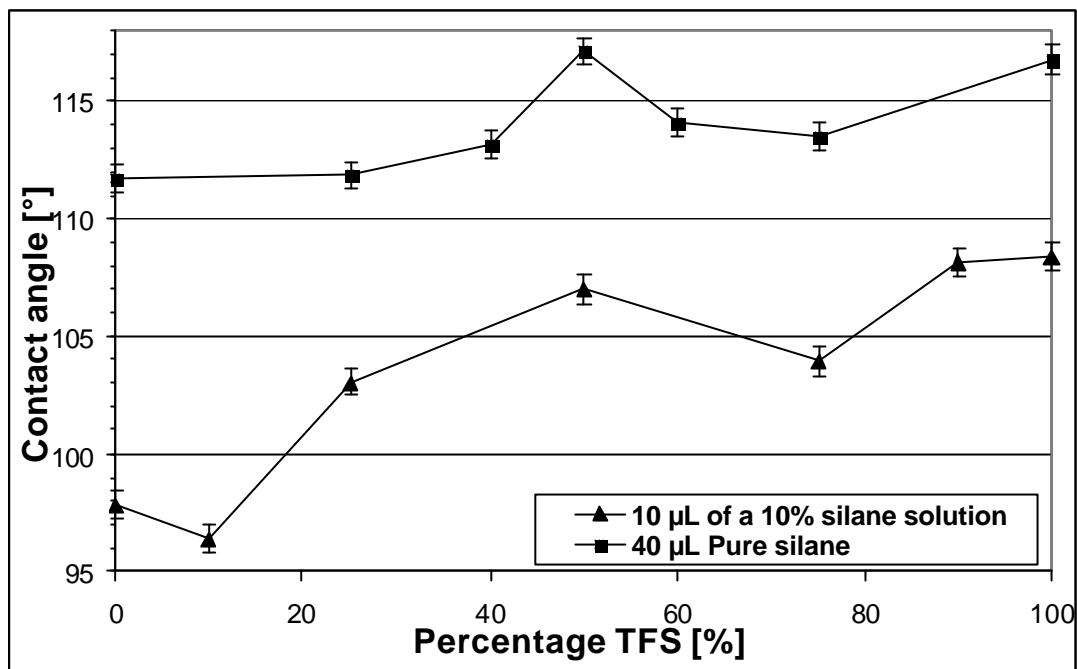


Figure 1. Water contact angles on flat Si surfaces as a function of TFS ratio in the MFS/TFS mixture solution for two different total amounts of the silane mixture injected for the coatings.

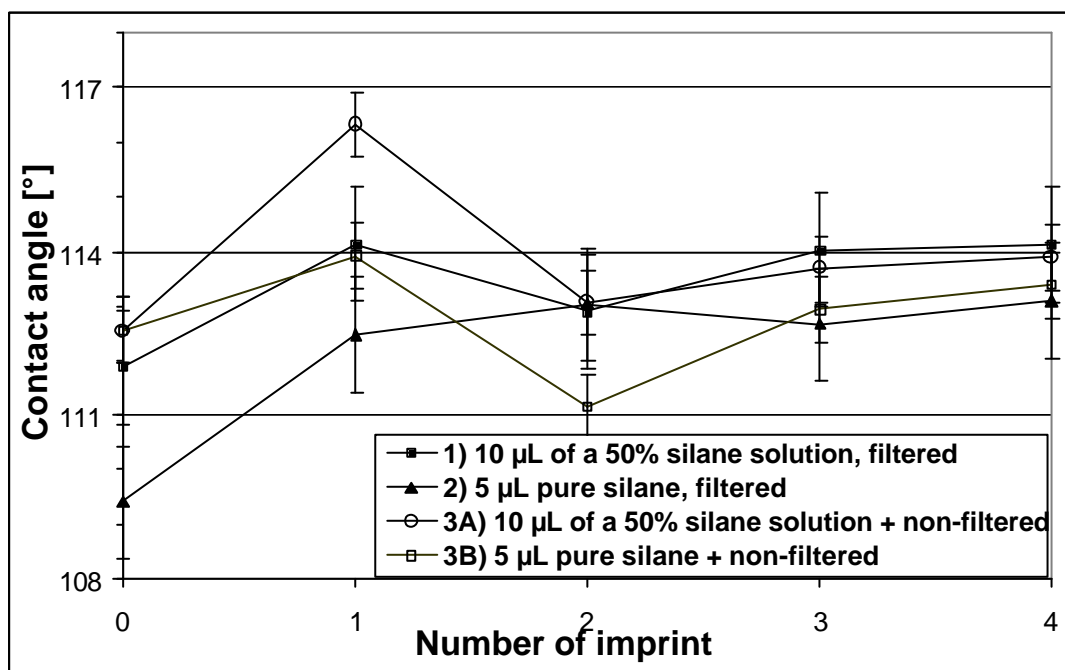


Figure 2. Water contact angles on flat Si stamps after imprints of PMMA resist. All stamps were coated with 1:1 mixtures of MFS/TFS but under different dilution (pure and 50% solution in toluene) and injection (direct injection or filtered by a micro-porous mesh) conditions.