NANOSTRUCTURED SELF-ASSEMBLED MONOLAYERS OF LONG-CHAIN ALKYLTRICHLOROSILANES ON Si

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Size reduction of electronics devices makes essential controlling the preparation of size-defined nanostructures. A promising solution consists in using molecular self-assembly. We present a non lithographic approach for preparing nano-devices on silicon from the self-assembly of a nanostructured molecular monolayer. These self-assembled monolayers (SAMs) are obtained by co-adsorbing two different molecules "A" and "B" from a liquid phase on a Si surface covered with a natural oxide. The study of the mechanisms of formation of nano-domains (phase separation) is performed for a system of binary (A:B) monolayers composed of n-alkyltrichlorosilanes with two different chain lengths [1,2] hence modifying the chain to chain van der Waals interaction. The main characteristics studied are the size, shape, and distribution of domains "A" in matrix "B". Those structural properties depend on several parameters such as the concentration ratio [A]/[B], the temperature, the duration, the solvent,… As deposited binary SAMs are studied using ellipsometry (thickness), contact angles (wetting), and atomic force microscopy (AFM).
We show that, below a critical temperature allowing molecular island growth, for a similar A/B chain length ratio a better phase separation can be achieved using long chains (A=30 with either B=20 or 18 carbon atoms) compared to shorter ones (A=18 with B=12 carbon atoms) [2]. Depending on the concentration ratio, it is possible to obtain dendritic islands of either the protruding longer "A" molecules (Fig. 1) or the shorter ones "B" forming holes (Fig. 2). These observations are interpreted by the growth of dense islands for both "A" and "B" molecules in the case of longer chains, whereas for the shorter (18:12) binary SAMs an homogeneous disordered phase of the shorter molecule was found to trap isolated longer ones, preventing them to gather with already formed islands [2]. These results are a step forward an essential complete separation of molecules "A" and "B" into size controlled nano-domains acting as a pattern for building molecular devices.
Modifying the functionality of the domains by changing the moieties of the grafted molecules in a selective chemical way would allow us to build different devices such as molecular diodes [3] and nano-transistors by grafting a conjugated oligomer on top of the alkyl chains [4]. The advantage of this Si-molecules hybrid approach of nanoelectronics is to be compatible with the well-known Si technology regarding applications.

References:

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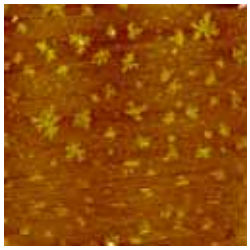

Figure 1 *: AFM image showing C_{30} islands in a C_{18} SAM. $[C_{30}]/[C_{18}]=1$ (image size : 10x10µm²)*

Figure 2 *: AFM image showing C_{18} islands in a C_{30} SAM. $[C_{30}]/[C_{18}]=20$ (image size : 10x10µm²)*