FORMATION OF NANO DOMAINS IN ALKYLTRICHLOROSILANE SELF-ASSEMBLED MONOLAYERS DEPOSITED ON SILICON : APPLICATION TO MOLECULAR ELECTRONICS

S. Desbief [1], L. Patrone [1], D. Goguenheim [1], D. Vuillaume [2]

[1] L2MP - Laboratoire Matériaux et Microélectronique de Provence - UMR CNRS 6137 / ISEN - Institut Supérieur de l'Electronique et du Numérique
Maison des Technologies, Place Georges Pompidou, 83000 Toulon (France)
[2] IEMN - Institut d'Electronique, de Microélectronique et de Nanotechnologie - UMR CNRS 8520, Avenue Poincaré, BP 69, 59652 Villeneuve d'Ascq cedex (France)

Phone: +33 4 940 38950, Fax: +33 4 940 38951
E-mail: simon.desbief@l2mp.fr
http://www.l2mp.fr

Size reduction of electronics devices makes essential controlling the preparation of size-defined nanostructures. Today, limits of conventional lithography techniques as well as their costs are major obstacles to get over in order to go further in the integration of electronics chips. 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[1-3] hence modifying the chain to chain van der Waals interaction, and also for varied headgroups which control the kinetics of grafting. 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 locally. We show that, below the critical temperature allowing island growth, for the same 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)[3]. Depending on the concentration ratio, it is possible to obtain dendritic islands of either the protruding longer "A" molecules or the shorter ones "B" forming holes. 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[3]. 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[4] and nano-transistors by grafting a conjugated oligomer (channel) on top of the alkyl chains[5]. The advantage of this Si-molecules hybrid approach of nanoelectronics is to be compatible with the well-known silicon technology regarding applications.

References

1. J.H. Miernik., K.K. Chittur, J. Weimer, *SAE Transactions 104* (1995) 1192
2. B.L. Kropman, D.H.A. Blank, H. Rogalla, *Langmuir 16* (2000) 1469-1472
3. L. Breuil, *Ph.D. Thesis, University of Sciences and Techniques Lille Flandres-Artois* (2000)
4. S. Lenfant, C. Krzeminski, C. Delerue, G. Allan, D. Vuillaume, *Nano Lett. 3* (2003) 741-746
5. J. Collet et al., *Appl. Phys. Lett. 76* (2000) 1339-1341