Mixed $(CH_2)_9$ -CH_3 /$(CH_2)_{10}$ -COOH monolayers on Si(111) surfaces for sensors applications.

C. Henry de Villeneuve, P. Allongue
UPR15 CNRS Université Paris VI 4 Place Jussieu
74252 Paris Cedex05 – France

R. Boukherroub*, D. D. M. Wayner,
Steacie Institute for Molecular Science, NRC Ottawa
K1A 0R6 Canada

*Present address : LPMC Ecole Polytechnique
Palaiseau France

Chemical functionalization of hydrogenated silicon surfaces rapidly proved to be a promising approach for the development of new integrated devices and sensors. Organic layers offering specific end-groups on their top and covalently attached to the silicon substrate should open new possibilities for the detection of chemical or biological recognition in sensors applications.

In this work, we investigated the structural and electrical properties of pure and mixed monolayers of alkyl chain $(CH_2)_n$ X with X = CH_3 and/or X = COOH end group grafted directly onto atomically flat H-Si(111) surfaces using chemical or photochemical previously reported procedures [1,2].

In situ capacitance measurements on modified electrode confirm the high compactness and the great stability of -CH_3 terminated layers and as well as the excellent electronic properties of the interface with a very low density of surface states. Capacitance measurements are sensitive to layer thickness and the expected linear increase of the inverse of the interfacial capacitance ($1/C_i$) is observed with increasing number of (-CH_2) group in the alkyl chain.

By comparison much less dense layers are obtained with COOH terminated layers. As a result, the properties of the interface rapidly degrades in an environment compatible with biological systems (buffer solution of neutral pH). We obtained a strong improvement of the molecular packing by using mixed CH_3/COOH layers. Mixed CH_3/COOH layers are indeed more densely packed with a compactness close to 100% as for the methyl layers. The layers are stable and resist to oxidation even in solutions of pH 8 since reproducible capacitance measurements can be performed in the accumulation regime without any noticeable degradation of the interfacial properties (Fig.1). In addition, the reactivity of the -COOH immobilized surface group is preserved. Indeed, reacting them with primary amines leads to a variation of C_i, as it is illustrated on Figure 2.

Further characterizations including AFM observations of the surface distribution of COOH groups will be presented at the conference

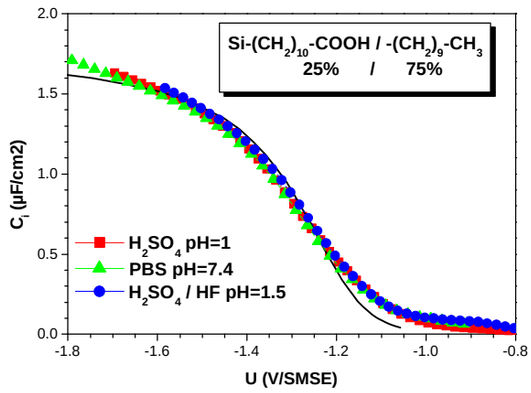

Figure 1 : Capacitance – voltage curve of Si(111) modified with a mixed CH_3/COOH monolayer in pH 1, 1.5, and 7.4 solutions.

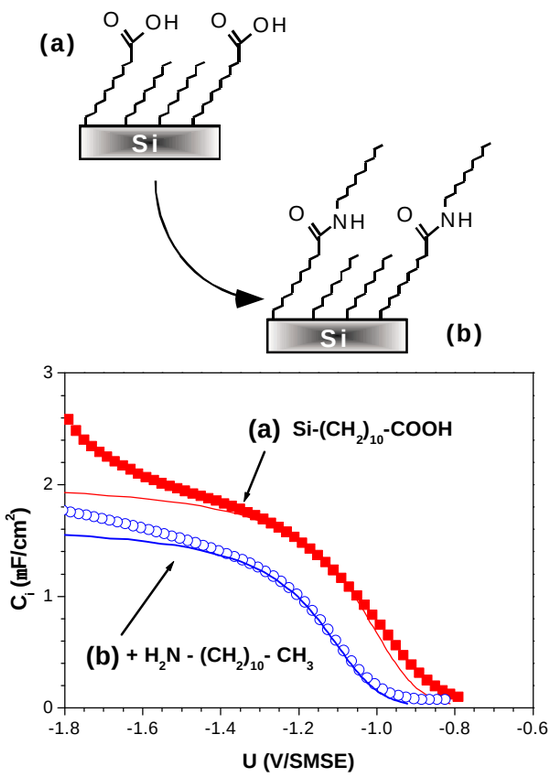

Figure 2 : Detection of chemical addition of undecylamine on acid modified Si surface by capacitance measurement. Interfacial capacitance C_i (a) before and (b) after addition of undecylamine

(1) R.L. Cicero, C.P. Wade, M.R. Lindford, C.E.D Chidsey, Langmuir (2000), 16.
(2) R. Boukherroub, S. Morin, F.Bensebaa and D.D.M. Wayner, Langmuir 1999, 15.