Organic Functionalization of Porous Silicon Nanostructures

Rabah Boukherroub

Interdisciplinary Research Institute (IRI), IRI-IEMN
Avenue Poincaré - BP 69
59652 Villeneuve d'Ascq, France
Tel: +33 (0)3 20 19 79 87
Fax: +33 (0)3 20 19 78 84
E-mail: rabah.boukherroub@iemn.univ-lille1.fr

Organic derivatization of semiconductor surfaces is a very active field of research because of the role of these materials in modern technology. Chemical functionalization of semiconductor surfaces has many potential applications ranging from surface passivation and stabilization to development of new strategies for immobilization of either chemical or biological species on the surface and detection of diverse interactions characterizing biological and chemical systems. Silicon-based structures are capital for such applications, because they offer the possibility for using the well-established microfabrication methods for integration of chemical and biological functionality into microelectronics platforms. Moreover, porous silicon (PSi) has the advantage of its high surface area and was found to be photoluminescent and electroluminescent.[1] Potential applications based on electrical and/or optical measurements for sensing chemical and biochemical interactions on the surface have been demonstrated using PSi.[2,3] More recently, an important step toward utilization of PSi for biomedical applications has been achieved. Canham et al. have shown that PSi layers of low porosity are active in vivo and that hydroxyapatite could be grown on the PSi matrix.[4-6]

Hydrogen-terminated PSi surfaces prepared by electrochemical dissolution of crystalline silicon in HF-based solutions exhibit very good electronic and optical properties.[1] However, these properties are affected by the chemical transformations occurring upon exposure of these surfaces to ambient air. Slow oxidation of the surface tends to deteriorate the good properties of this material. Several methods including deliberate oxidation under controlled thermal or electrochemical conditions have been elaborated to stabilize the porous matrix.[7]

Recently, much effort has been devoted toward PSi passivation using chemical derivatization of the freshly prepared surfaces by replacing silicon-hydrogen (Si-H*x*) bonds with more stable Si-C or Si-O-C bonds, under various conditions.[8] The organic-modified PSi surfaces have shown a very good stability in different organic and aqueous buffered solutions. This high improvement in the stability is a real asset for future applications of the resulting hybrid materials (PSi/organic monolayer).

We have used a thermal treatment to functionalize the PSi surface with a high coverage.[9,10] This technique is simple to carry out and tolerates different functional groups (ester and acid functional groups).[11,12,13] We have successfully used this approach to stabilize the photoluminescent properties of the PSi surface,[14] as well as the electroluminescence (EL) efficiency and EL output intensity of a PSi-based diode under continuous operation.[15]

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