Nanocomposite porous silicon layers

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ABSTRACT

Porous silicon (PS) layers formed on the crystalline Si substrates by electrochemical etching have been known for many years, due to their unique optical properties. PS properties are strongly dependent upon size and shape, and are controlled by quantum size effects. Moreover, PS is a biocompatible material. The study of the porous silicon (PS) structures is important for both fundamental understanding of nano-systems as well for its potential applications. This paper is a review of our experimental works on PS based composite layers with the aim to enlarge their applications, especially in sensor and biomedical fields.

KEY WORDS: Porous silicon; nanostructured silicon; nanocomposite layers; sensors; biomedical applications;

INTRODUCTION

Porous silicon (PS), also known as nano-structured silicon generally, is fabricated by electrochemical anodization of bulk Si wafers in diluted aqueous or ethanoic hydrofluoric acid (HF). It has all the advantages of Si with regards to planar technology (integration of signal processing circuitry or low cost) and added advantages corresponding to a nanostructured material (high surface area or greater adsorption properties).

At the beginning, due to its interesting tunable photo- and electroluminescence characteristics discovered by Canham (1990), PS was studied as a new material for optoelectronic devices (Cullis, Canham, Williams, Smith, and Dosser, 1994; Canham, Cox, Loni, and Simons, 1996; Bisi, Ossicini, Pavesi, 2000; Ossicini, Pavesi, Priolo, 2003). In the last years, PS has attracted much attention because of its biocompatible, bioactive and biodegradable nature (Canham, 2001; Canham, Aston, 2005; Worsfold, Voelcker, Nishiya, 2006). In the future it is expected that PS to become the bridge that allows signals and information to be transmitted between a semiconductor device and a biological system.

In this paper, various PS based composite layers experimented in our group, are presented in order to enlarge the PS applications, especially in sensor and biomedical fields. We have investigated the following nanocomposite layers: (i) porous silicon oxidized dielectric membrane for sensors (Kleps, Angelescu, Miu, 1999); (ii) DLC- PS composite layers for field emission (Kleps, Angelescu, Samfirescu, Gil, Correia, 2001) and for cell adhesion; (iii) PS conductive and biocompatible composite structures for electrode applications; (iv) biocompatible and bioactive PS- mineral calcium-phosphate composite layers for tissue engineering applications (Kleps, Angelescu, Miu, Simion, Moldovan, Kulkarni, Paduraru, Petrescu, Mihaljescu, Neghina, Bragaru, Teodosescu, Socol, 2003); (v) biocompatible and bioresorbable PS-metallic layers (Fe, Ag, Mg, K) for microelement controlled delivery (Angelescu, Kleps, Miu, Simion, Negina, Petrescu, Moldovan, Paduraru, Raducanu, 2003); (vi) gold (silver)/Si nanocomposite layers with applications in biology (Kleps, Danila, Angelescu, Miu, Simion, Ignat, Bragaru, Dumitru, and Teodosiu, 2007); (vii) S-layers – mesoporous silicon matrix.

POROUS SILICON OXIDIZED DIELECTRIC MEMBRANE FOR SENSORS

The oxidized porous silicon (OPS) layers can be taken into consideration as an alternative method for dielectric membrane preparation. The main advantage of this method is the possibility to obtain thick dielectric layers, of different thickness (2-20 μm), in a short period of time, using simple and chip processes, as follows: (i) selective Si porosification; (ii) PS oxidation; (iii) OPS densification. By chemical microfabrication we have realized different OPS membranes (Fig. 1).

![Fig. 1. SEM image of the oxidized porous silicon (OPS) layer after thermal oxidation at 975°C in dry O₂ and densification at 1100°C in N₂ atmosphere.](image-url)