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Title of the thesis: Raman and Photoluminescence Investigation of Nanostructured Porous Silicon for Sensing Organic Vapours

Abstract:

Porous silicon (PS) is an interesting material from both fundamental and application point of view. It is well known for its notable features like room temperature photoluminescence (PL), large surface to volume ratio, apparent size-dependent bandgap and surface reactivity. These features arise from the quantum size effects which occur when the size of silicon crystal is squeezed from a larger dimension to a *nano* (10^{-9}) dimension. When these quantum size effects are introduced in the surface, more popular 'porous silicon' is formed exhibiting astonishing results. PS didn't get much popularity until Prof. Canham and his team discovered the bright luminescence from PS at room temperature. This process was described under simple experimental setup and conditions. After PS got its fame, its exclusive characteristics were being utilized in many electronic and biocompatible applications. Its use in optoelectronics, sensing devices, wafer technology and many more fields made it very accessible to the industry.

This thesis aims to work on the surface reactivity of PS for sensing applications. Various anodization conditions which prepared a variety of PS morphologies were tested. The morphologies were studied using Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), Raman and Photoluminescence (PL) Spectroscopy. Fourier Transform Infrared (FTIR) spectroscopy was used for understanding the chemical composition of the PS surface. The hydrophobicity of the PS surface was estimated by contact angle

measurements. The interactivity of the organic molecules with the surface was well described by such studies. The sensing was specifically tested in presence of organic vapours. All the steps from the affinity of the PS surface for organic vapours to the adsorption of vapours on the surface were thoroughly studied. PS surface is known for its instability because of the oxide layer that is formed rapidly after anodization. Efforts were made to stabilize the surface by a slight variation during fabrication process. The surface was illuminated while fabrication and this had shown profound effect on the surface. These samples had shown immense stability and had shown similar results after repetitive exposure to organic vapours. The vapours tested were categorized as linear aliphatic alcohol chain length (methanol to n-octanol), acetone and water. The experiments were also done in presence of water to understand the sensing mechanism in presence of solvents of different physical and chemical characteristics.

The thesis comprises of two types of sensing: optical and electrical. In optical sensing, PL quenching technique was employed for realizing the optical property called PL of PS. The PL quenches drastically on exposure of an organic vapour. The other technique exploited was electrical which is dependent on the capacitive behaviour of PS. The highly resistive PS plays the role of a dielectric sandwiched between two parallel plates (ohmic contacts). On exposure of any organic vapour, the dielectric of the PS layer changes causing a change in the sensitivity. On completion of all optical and electrical sensing, it was concluded that the major role played in any sensing pattern is the attraction of the organic molecule towards PS surface which in turn are completely dependent on the respective chemical and physical backgrounds.