Porosity Dependence of the Absorption Coefficient and Quantum Confinement of Porous Silicon Nanostructures in HF Solutions

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Porous silicon (PSi) formed by electrochemical etching of lightly-doped silicon substrates in hydrofluoric acid (HF) exhibits a sponge-like nanostructure. It has potential applications in optoelectronics and photovoltaics because of new properties emerging from quantum confinement (QE), such as light emission and tunable optical absorption. PSi nanostructure typically exhibits a broad distribution of sizes due to its disordered nature. After PSi formation, further chemical dissolution in HF can be used to increase the porosity and thus reduce the sizes. Here we monitored the PSi dissolution in-situ in HF using photoconduction analysis. This photoconduction technique can be used to measure the PSi optical constants[1]. Figure 1 shows the time evolution of the photocurrent during PSi dissolution. A saturation current was observed when the whole PSi layer had been dissolved, meaning the porosity had reached 1. Using a model based on data from the literature, we could establish a relation between the elapsed time and the porosity change. Then the evolution of the absorption coefficient with porosity could be derived, and is shown in Fig. 2. The results were compared to the literature and discussed, referring to the effects of QE and surface states. Our technique is the only one so far allowing the determination of the absorption of PSi over a very wide range of porosities, including so far unexplored ultra-high porosities, while preserving the integrity of the nanostructure and avoiding any contamination of the surface. It also allows the determination of the kinetic of PSi dissolution for different HF concentrations[2].

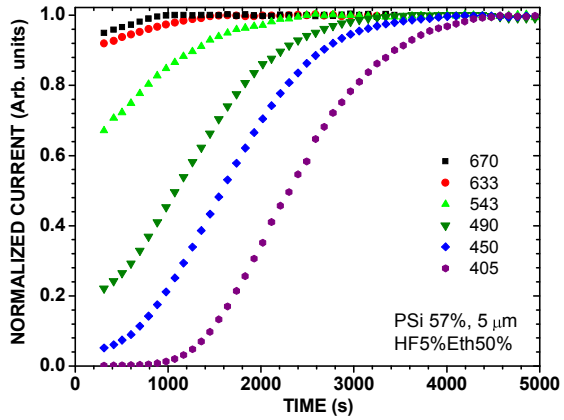

Fig.1: Normalized photocurrent as a function of dissolution time for indicated conditions and illumination wavelengths.

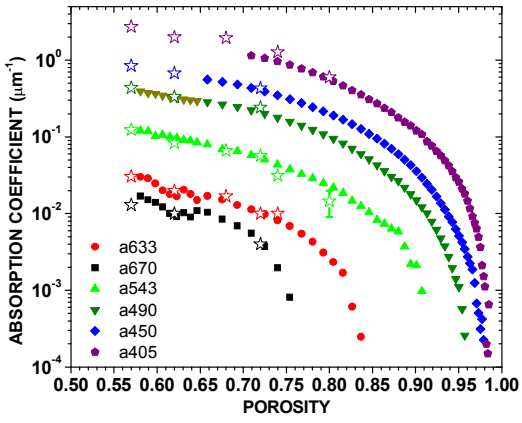

Fig.2: Absorption coefficient of PSi as a function of porosity determined using the model described in the text (solid symbols) or from direct measurements (hollow symbols).

[1] B. Gelloz, H. Fuwa, and L. Jin, ECS Journal of Solid State Science and Technology **5** (3), 190 (2016)
[2] B. Gelloz, K. Ichimura, H. Fuwa, E, Kondoh and L. Jin, ECS Journal of Solid State Science and Technology **6** (1) (in press; doi: 10.1149/2.0321612jss)