

Stabilization of porous silicon in aqueous buffer using atomic layer deposited hafnium oxide

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As porous silicon (PSi) is widely used for sensing and biosensing applications, it is often exposed to aqueous media. Unfortunately, PSi is unstable in presence of water due to the oxidation/dissolution of the Si scaffold, which leads to significant shifts in its optical properties and thus prevents an accurate reading of measurements for a sensitive detection [1]. Several methods modifying the PSi chemistry have been successfully applied to solve this issue, such as the carbonization [2], hydrosilylation [2] and ozone oxidation [3] with the most used being the thermal oxidation [1].

However, when using the thermal oxidation method, *i.e.* oxidizing the PSi layer at 800 °C for 1 hour, we noticed that this method presents a significant drawback. Indeed, due to the relatively low optical index of SiO₂, $n = 1.42$, the PSiO₂ layer exhibits a low contrast when immersed in aqueous media such as Phosphate Buffered Saline (PBS), whose optical index is 1.34. This leads to small Fabry-Pérot fringes due to weak light interferences, which renders the measurements very sensitive to noise.

This work thus focuses on the use of atomic layer deposition (ALD) of hafnium oxide to passivate the internal surface of PSi layers while maintaining a high contrast in aqueous media to ensure an efficient and sensitive detection. ALD is a method of choice due to its high conformality of coating for high aspect ratio nanostructures and its precise thickness control down to the angstrom due to its self-limiting mechanism [4]. In this research, we compared the stability of PSi layers in PBS over time, both for PSi oxidized at 800 °C and for PSi coated with a 8.5 nm thick layer of HfO₂. For both scenarios, we observed a shift in effective optical thickness of the same magnitude (Fig. 1), while the variation from one measurement point to another is significantly reduced to the PSi/HfO₂ layer. The noise level and the signal-to-noise ratio (SNR) were then computed with the SNR for the PSi/HfO₂ layer being 10 times smaller than for the PSiO₂ layer. This difference in SNR could ultimately lead to an improvement of the limit of detection for biosensors operating in aqueous media.

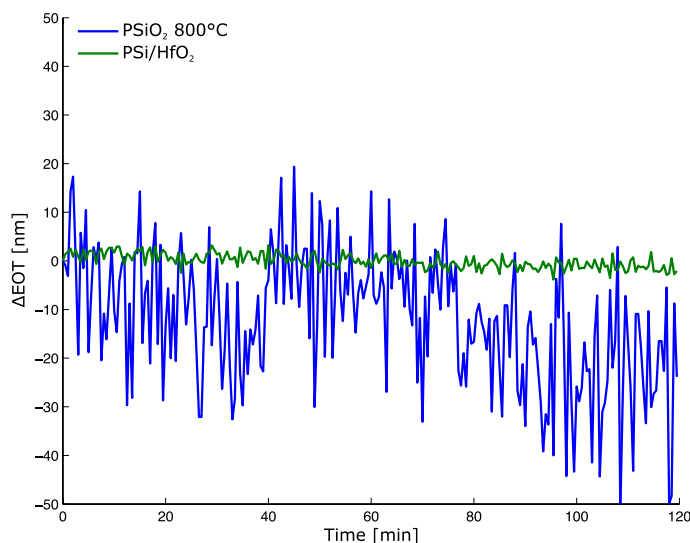


FIG. 1 – Stability over time of PSi in PBS: (blue) PSi oxidized at 800 °C for 1 hour, (green) PSi coated with HfO₂.

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