In-situ Porous Silicon Interface Roughness Characterization by Laser Interferometry

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In-situ measurement of interface roughness, etch rate and porosity during etching of porous silicon (PS) single films by an interferometric technique is reported. By measuring the reflected intensity of an IR laser diode from the backside of a Si samples during electrochemical etching (HF, water, ethanol electrolyte with constant current density) of PS, a signal containing interference between beams reflected off the different interfaces in the sample is obtained. Figure 1 shows a schematic of the different beam trajectories in the sample.

The signal is made up of different frequency components which are found and analyzed by Short-Time Fourier Transform (STFT). The main frequency components are identified to be due to interference of the main beams shown In Fig. 1. From an analysis of these frequency components the etching rate can be found as well as the porosity of the layer and the PS/substrate interface roughness. An example of an STFT spectrum is shown in Fig. 3. The interference of beam I and III in Fig. 1 makes up the frequency partial labeled 1 in Fig. 3, and that of I and II is labeled 2.

The amplitude of each component is dependent on the fresnel reflection and transmission coefficients and the roughness of each interface the beams encounter. As the etching proceeds, the roughness at the PS/substrate interface increases thereby decreasing the interference amplitude. We calculate the RMS value of this roughness from amplitude data of the main components by applying Davies-Bennett theory. Figure 4 shows the decreasing signal amplitude with time for samples etched with different concentrations of HF and glycerol, this is proportional to the RMS value of the roughness. The calculated roughness values are compared to profilometer measurements of the PS/substrate interface after the PS layer is stripped away by NaOH.

The methods derived are useful for calibrating and optimizing PS optical building blocks such as filters, Bragg mirrors and waveguides.

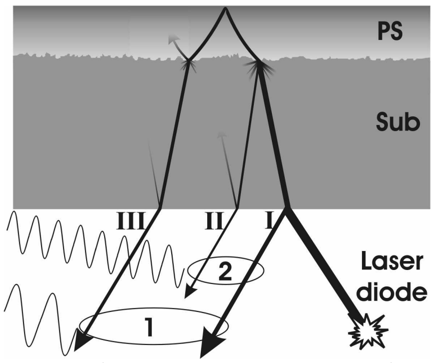

Figure 1. Schematic of the beam traces during *in-situ* reflectance.

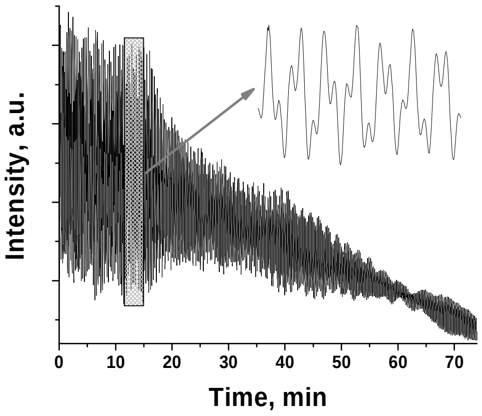

Figure 2. An example of a measured reflectance signal showing the superposed pattern of interference between multiple beams.

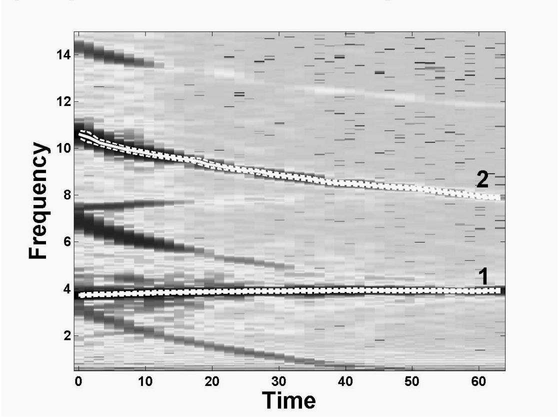

Figure 3. The result of the Short-Time Fourier Transform of the signal in Fig. 2. The interference from situation 1 and 2 in Fig. 1 are traced and indicated in the spectrogram.

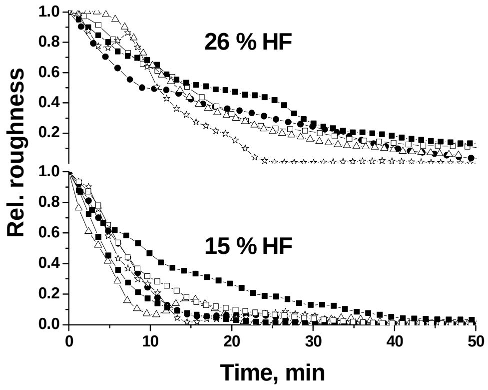

Figure 4. The amplitude profiles of signal 1 in Fig. 3 for samples etched with different HF and glycerol concentrations. The decrease in amplitude with time is an indication of increasing roughness in the PS/substrate interface.