Fabrication of Luminescent Porous Silicon Layers Using Extremely Dilute HF Solutions

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Light emitting porous silicon (PSi) layers can be formed by anodically etching Si wafers in HF solutions. In most cases concentrated (10-50 %) HF solutions are used. Zhang *et al.*[1] have measured the critical current densities for the formation of PSi layers over a wide range of HF concentration. Their results show that the critical current densities do exist at HF concentrations as low as 0.1%. This implies that PSi layers can be formed with these extremely dilute HF solutions. In their paper, however, no information is given on the luminescence properties of their PSi samples. Luminescent PSi layers prepared with dilute HF solutions are especially beneficial for applications in the field of education.[2] In this study, we have confirmed that efficient luminescence can be obtained for HF concentrations down to 0.1%. We have also found some other advantages of preparing luminescent PSi layers in such dilute HF solutions.

Figure 1 shows the photoluminescence (PL) intensities of PSi samples prepared at different HF concentrations and etching current densities. It is shown that efficient PL can be obtained at HF concentrations down to 0.1%. In the case of 0.1 % HF, the most efficiently luminescent sample can be obtained at a very low etching current density of ~ 0.1 mA/cm^2. This is due to reduced critical current densities as reported by Zhang *et al.*[1] It should be noted that such low current densities can never be used to obtain luminescent PSi layers at high HF concentrations. The use of dilute HF solutions, therefore, is advantageous to obtain a thin layer of luminescent PSi by a reduced etching current density.

Figure 2 shows PL spectra of two different PSi samples prepared with 0.1% HF. In addition to p-type wafers, n-type wafers can be etched into luminescent PSi layers without illumination.

The fact that luminescent PSi layers can be formed at very low etching current densities can also be utilized to obtain luminescent PSi layers without external bias. We have formed PSi samples on n-type wafers under short-circuit conditions. The etching current was provided by the short-circuit photocurrent resulting from illumination performed during the etching procedures. As shown in Fig. 3, luminescent PSi layers can be obtained at illumination intensities as low as ~ 0.02 mW/cm^2. These intensities are remarkably smaller than those required to form luminescent PSi layers by open-circuit photochemical etching.[3]

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[1] X.G. Zhang, S.D. Collins, and R.L. Smith, J. Electrochem. Soc. **136**, 1561 (1989).
[2] V.P. Parkhutik and L.T. Canham, Phys. Stat. Sol. (a) **182**, 591 (2000).
[3] N. Noguchi and I. Suemune, Appl. Phys. Lett. **62**, 1429 (1993).

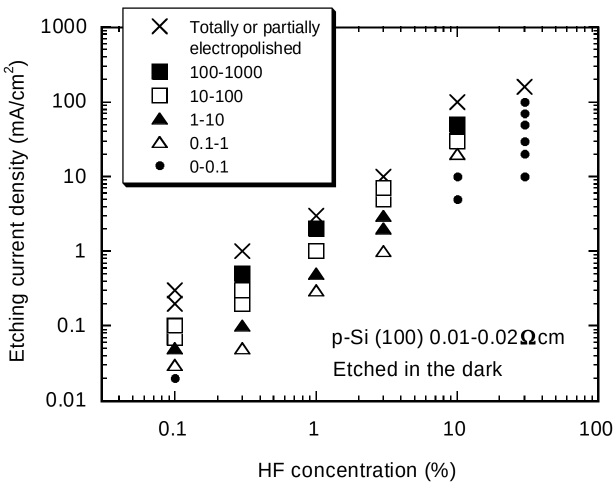

Fig. 1. PL intensities of PSi samples prepared with different HF concentrations and etching current densities. The PL intensities are classified into five grades and shown with different symbols. Crosses indicate samples that have suffered from partial or total electropolishing.

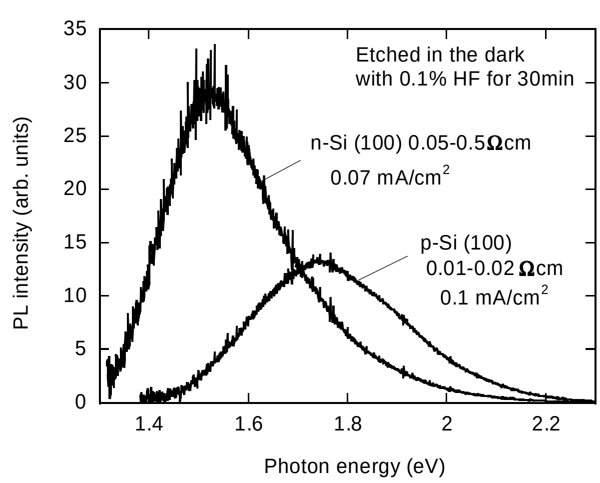

Fig. 2. PL spectra of two PSi samples prepared with 0.1% HF.

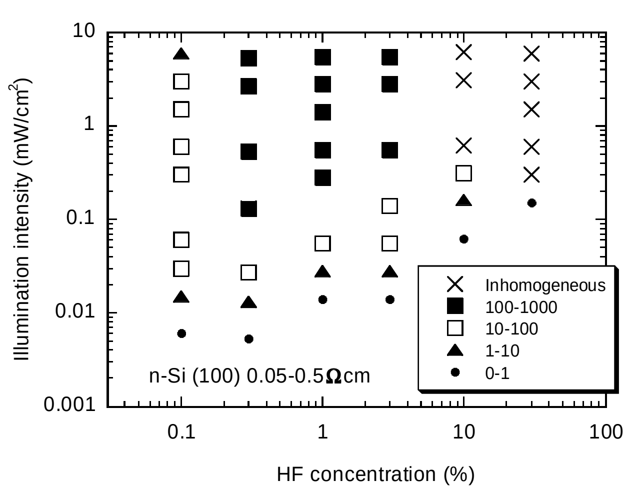

Fig. 3. Results of the short-circuit photoelectrochemical etching. Measured PL intensities are graded and plotted with different symbols.