NONRADIATIVE RECOMBINATION AND BAND BENDING AT SI SURFACES DURING ELECTROCHEMICAL ETCHING IN ACIDIC FLUORIDE SOLUTIONS

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Abstract

In-situ photoluminescence (PL) and in-situ photovoltage (PV) measurements are used to investigate the PL quenching by nonradiative (nr) surface recombination and the band bending of Si during electrochemical etching in aqueous HF-containing solutions.

Fig. 1 shows the current, the PL intensity and the photovoltage amplitude of p-Si(111) in 0.1 M NH_4F (pH 2) as a function of the applied potential. Hydrogen evolution occurs at cathodic potentials (A). The onset of the porous silicon formation in dilute acidic NH_4F-solutions (B) is accompanied by a decrease in nr surface recombination. Intensive electrochemical etching leads to an increase of nr surface recombination, to positively charged surface states and to a strong increase of the current density (C). Electropolishing dominates at position (D).

The evolution of hydrogen and its penetration into near surface regions [1] lead to the formation of nr surface defects [2]. The lowest nr surface recombination in the regime of porous silicon formation (B to C) has been observed in higher concentrated HF solution even at high current densities as plotted in fig. 2. This figure shows the PL intensity as a function of the current flow and the amount of HF in the solution used. Therefore, the intermediates of the reactions which lead to pore formation are rather of ionic nature than like Si dangling bonds, so that a high amount of H^+-ions passivate nr active defects.

In addition, the increase of the current density is higher than expected for an ideality factor of 1, what gives evidence for a decrease of the effective barrier height during porous silicon formation.

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2. J. Rappich, T. Dittrich, Y. Timoshenko, I. Beckers, and W. Fuhs, Mat. Res. Soc. Symp. Proc. **452**, 797 (1997)

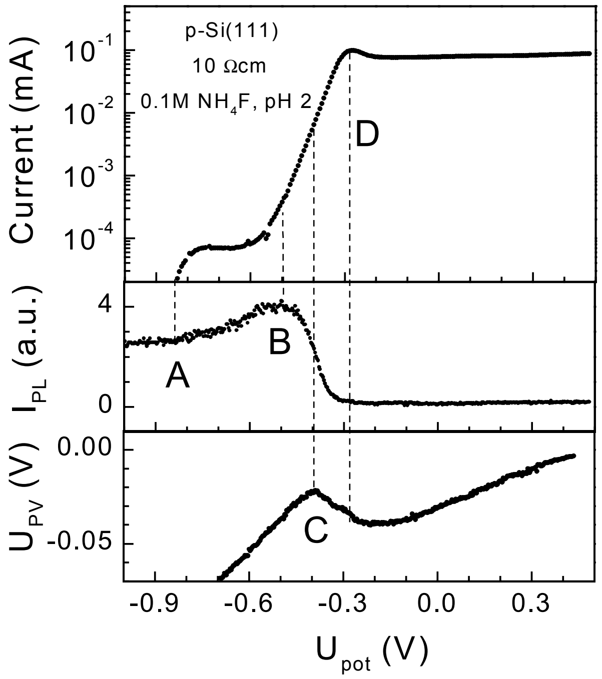

Fig. 1: Current, PL intensity (I_{PL}) and photovoltage amplitude (U_{PV}) of p-Si(111) in 0.1 M NH_4F (pH 2) as a function of the applied potential.

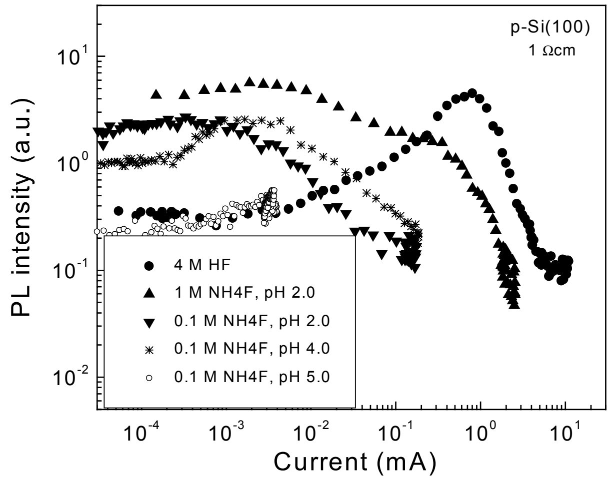

Fig. 2: PL intensity as a function of the current flow in different NH_4F-containing solutions (decrease in pH and increase in the amount of NH_4F increases the HF-concentration).