Fast IV Measurements during the Growth of Porous Structures in Ge, InP, and GaAs

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In situ monitoring of electrochemical pore formation allows to analyze the underlying growth mechanisms and could be used for an in situ control of pore growth needed for stabilizing the pore formation. Only very few in situ techniques are available to monitor the pore formation process, mainly due to two problems: 1) Pore formation constantly changes the sample surface; standard IV measurements thus contain some drift disturbing the results; 2) Pore formation always needs a nucleation phase with a usually long time constant, so changing the voltage for a significant time will disturb the pore growth process since a new nucleation cycle might be necessary after each measurement.

It is well known that in order to obtain good macro pores, the etching conditions at the pore tips should be kept at optimal conditions within narrow margins. Taking standard IV measurements with slow scan rates of 0.1 to 1 V/s will lead to large deviations from the optimal etching condition and normally quench pore growth. The information contained in such slow IV-curves thus will not reflect the growth conditions of pores. To avoid this problem, the IV-measurement procedure must be much faster, i.e. the scan time should be less than 50 ms. This kind of voltametry is called fast voltametry.

Fast IV-curves, however, could be corrupted by capacitive currents due to charging or discharging of the interface. But for standard pore growth condition with relatively high current densities this proved to be no problem. In contrast to slow IV curves, the fast measurements will not reflect the potential dependence of the steady state condition at the semiconductor electrolyte interface, e.g. the oxide coverage can not change significantly in one 50 ms loop; they just reflect the possible current flow for various potentials for the actual state of the interface, generating a snap shot of the interface and the actual stage of pore growth.

Since the scan during fast voltametry only lasts for a few milliseconds, such scans can be repeated many times while the pores are gradually growing into the depth without disturbing their growth condition. By comparing the IV-curves at different stages of their growth, i.e. a different thickness of the porous layer, it is possible to monitor the etching conditions.

To the best of the authors knowledge, no fast IV measurements performed during pore growth in semiconductors have been reported up to now. In this paper we will present fast IV measurements during the formation process of the so called current line oriented pores in InP [1], and crystallographically oriented pores in GaAs [1, 2] and Ge.

Figure 1 summarizes examples of fast IV-curves during pore growth in several semiconductors. In InP and GaAs the current decreases while pores grow into the substrate, whereas for Ge the fast IV current is increasing.

The results for InP and GaAs can easily be understood when taking into account that these pores grow extremely stable. Chemical dissolution takes place only at the pore tips and the etching geometry does not change any more after the pore nucleation [3]. Thus the active area stays constant and only the distance between the pore tips and the sample surface increases monotonically. The reduction of current in the corresponding fast IV curves just reflects the monotonically increasing diffusion limitations.

In Ge no stable pore growth has been found up to now, the diameter of all pores is increasing as well and “parasitic” electro polishing occurs at all surfaces of the sample. Thus pore growth leads to a monotone increase of the active area which is mirrored in the increase of the fast IV currents found for pore growth in Ge.

Thus the fast IV curves and the resulting pore morphologies give a consistent picture of the etching conditions for pores in III-V compounds and Ge. Further quantitative analysis of the fast IV- curves will be presented to support this results.

References

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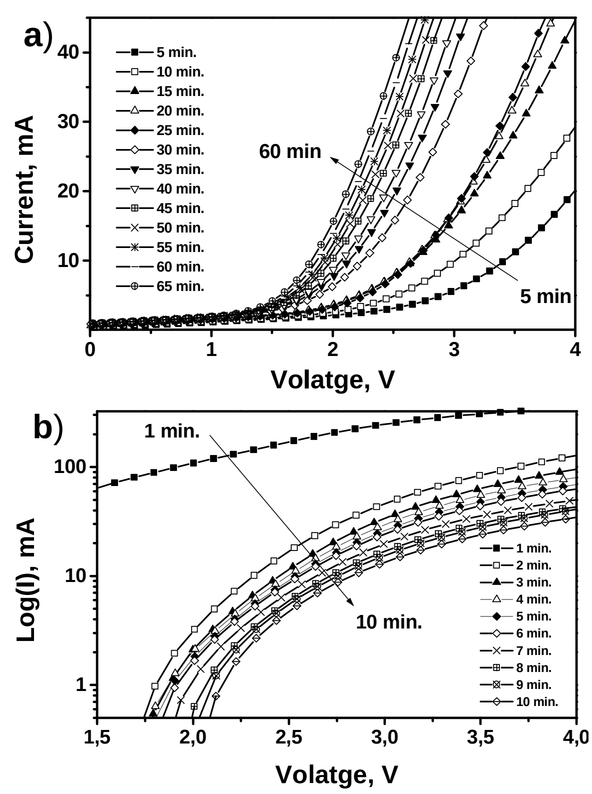

Figure 1. Fast IV curves. a) Ge; the fast IV curves are shifted upwards with time; b) InP; the fast IV curves are shifted downwards with time. The scan rate was 0.2 V/ms