IMPEDANCE SPECTROSCOPY AS A POWERFUL TOOL FOR BETTER UNDERSTANDING AND CONTROLLING THE PORE GROWTH MECHANISM IN SEMICONDUCTORS

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Abstract: This work shows new results towards a better understanding of macropore growth in semiconductorphenomenology by using *in-situ* FFT impedance spectroscopy. A new interpretation of the voltage impedance is proposed. In particular, the pore quality could be quantified for the first time *in-situ*, especially by extracting the valence of the electrochemical process. The study paves the way towards an automatized etching system where the pore etching parameters are adjusted *in-situ* during the pore etching process.

Key words: FFT impedance spectroscopy, macropore, electrochemical etching

1. INTRODUCTION

The electrochemical pore formation in Si is a topic [1] with many potential applications and much progress was made towards the development of production technologies [2] and many product prototypes were advanced (see [3] and references therein). Nevertheless, despite all of this work, no product based on porous Si can be found on the market at present. Among the main reasons for this is the still not fully understood mechanism of pore

formation, or more generally, the many open questions in the field of electrochemistry of semiconductors. As an example, many envisioned applications demand precise control of the pore quality (e.g. diameter variations, pore wall roughness) and the present understanding of pore formation mechanisms, although rather advanced in some respects, does not ensure the full control of the etching process as it would be needed.

In this work, we show how impedance spectroscopy can be used for the purpose of controlling the macropore growth in n-Si. In particular, it is shown how one can extract the dissolution valence at the pore tips from the measured impedance. This number is used as a quantification of the pore quality. Determining this number *in-situ* can pave the way toward the implementation of an automatized etching system.

2. EXPERIMENTAL

n-Si wafer with low doping levels corresponding to a resistivity of 5 Ωcm are used for etching macropores. The substrate orientation is (100) with an n^+ layer on the backside of the wafer for good ohmic contact to the sample. The etching is done using backside illumination (BSI) [4]. The samples were pre-structured by standard photolithography before etching; the nucleation pattern was a hexagonal lattice with a lattice constant of a = 4.2 μm. The electrolyte consisted of 5 *wt.*% HF in an aqueous electrolyte. The temperature of electrolyte was fixed at 20°C. The FFT impedance spectrometer embedded with the etching system provided by the ET&TE GmbH, Germany was used to extract information concerning pore growth during the etching process.

3. RESULTS AND DISCUSSION

For voltage impedance a small perturbation signal is applied to the anodization voltage and the response in the etching current is measured. Fig. 1a shows the I-V curve of n-Si in contact with HF under BSI. One can easily see that a change in the voltage causes a variation in the current. Since during the macropore etching the etching voltage must be in the saturation regime of the IV curve [2], the linearity condition is fully fulfilled. However, another problem can be seen, i.e. being in the saturation regime, any perturbation in the voltage generates a minute variation of the current. In order to separate the measured signal from noise, strong requirements are imposed to the measuring hardware as well as data processing software.