Self-Organized Formation of Fractal and Regular Pores in Semiconductors*

Jens Christian Claussen[1,2], Jürgen Carstensen[1], Marc Christophersen[1], Sergiu Langa[1], and Helmut Föll[1]

[1] Chair for general materials science, CAU University of Kiel, Kaiserstr. 2, 24143 Kiel, Germany http://www.tf.uni-kiel.de/matwis/amat/

[2] Theoretische Physik und Astrophysik, Universität Kiel, Leibnizstr. 15, 24098 Kiel, Germany http://www.theo-physik.uni-kiel.de/~claussen/

Abstract. Electrochemical etching of semiconductors, beside technical applications, provides an interesting experimental setup for self-organized structure formation capable of regular, diameter-modulated, and branching pores. The underlying dynamical processes governing current transfer and structure formation are described by the Current-Burst-Model: all dissolution processes are assumed to occur inhomogeneously in time and space as a Current Burst (CB); properties and interactions between CB's are described by a number of material- and chemistry- dependent ingredients, like passivation and aging of surfaces in different crystallographic orientations, giving a qualitative understanding of resulting pore morphologies.

1 Electrochemical Etching: Basic Experimental Setup

The solid - liquid junction of Silicon and HF - containing electrolytes exhibits a number of peculiar features, e.g. a very low density of surface states, i.e. an extremely well "passivated" interface [1]. If the junction is biased, the IV - characteristics (Fig. 1) in diluted HF is quite complicated and exhibits two current peaks and strong current- or voltage oscillations at large current densities (for reviews see [2,3]). These oscillations have been decribed quantitatively by the Current-Burst-Model [4,5,6,7].

The PC controlled experimental setup is shown in Fig. 1. Using a four electrode arrangement, a potentiostat/galvanostat is contacting the sample and the electrolyte, allowing for a well defind potential resp. current for the electrochemical dissolution reactions. Backside contact, front- and/or backside illumination and electrolyte pumping can be varied as well as cell size (from under 0.3 cm up to wafers of 6 in), semiconductor material (Si, InP, GaAs, GaP) including various doping levels and crystallographic orientations. In addition, the electrolytes (e.g. HF, HCl, H_2SO_4) and their concentrations and temperature can be varied. With this setup a rich variety of porous semiconductors [8,9] can be generated, from nanopores to mesopores and macropores, and with various regular and branching structures.

Most of the phenomenonology can be well understood within the framework of the Current-Burst-Model which seems to reflect a number of quite general properties of semiconductor electrochemistry.

* Published in: Heike Emmerich, Britta Nestler, and Michael Schreckenberg (Eds.), Interface and Transport Dynamics - Computational Modelling. Springer (Berlin), Lecture Notes in Computer Science and Engineering **32**, 82–87 (2003).