INVESTIGATION OF CURRENT ORIENTED PORE GROWTH IN SILICON

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Electrochemical etching of silicon in HF containing electrolytes is a powerful tool to form well defined porous structures. Depending on the etching conditions a wide range of shapes and pore sizes from nm to several µm can be realized [1]. In this paper we deal with the formation of macropores, i.e. pores which, according to the IUPAC-definition, have diameters larger than 50 microns. In nearly all experiments these macropores strictly obey crystallographically defined growth directions (i.e. <100> or <113>) [2] while (111)-planes prove to be stopping planes. An exception is the work of Ponomarev et. al. [4] who achieved similar pores.

In the presented experiments we used standard (111) wafers and anodized them in a custom build etching set-up with a high performance potentiostat/galvanostat and in the case of n-type silicon using additional backside illumination. The resulting pore structures are investigated by optical and electron microscopy.

In two different configurations pores have been found in silicon which against almost all other experimental results and predictions in this field tend to grow in <111> directions. Similar pores have only been found in electrochemically etched III/V compounds (Langa et al. [3]). These so-called current line pores grow perpendicular to the surface and the pore tips just follow the direction of maximal current. The two configurations under which corresponding pores grow in silicon are:

1. Prestructured (hexagonal lattice) (111) p-type silicon samples. This lattice can force a closed packed nucleation and growth of pores with a very high density (cf. **Fig. 1 and 2**).
2. n-type silicon etched in a HF containing organic electrolyte (dimethyl formamide: DMF) with a strongly increased conductivity by adding a conducting salt (tetra butyl ammonium perchlorate: TBAP). These samples are additionally illuminated from the backside to generate the necessary electronic holes for the anodic reaction (cf. **Fig. 3**).

The parameter dependence and the processes leading to current line oriented pores have been investigated intensively for the III-V compounds. Several features like, e.g. the switching from crystallographically oriented to current line oriented pores at higher voltages have been found in silicon as well (cf. **Fig. 3**). It will be discussed if this model can be used to describe the current pore formation in silicon as well; the dependence on the etching conditions like prestructuring (see **Fig. 1,2**), the type of conducting salt, the etching potential and current, HF concentration and temperature will be considered in this context.

The results will be analyzed in the framework of the so called current burst model with particular emphasis on differences or similarities between corresponding pores in silicon and III/V-compounds, respectively.

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References:

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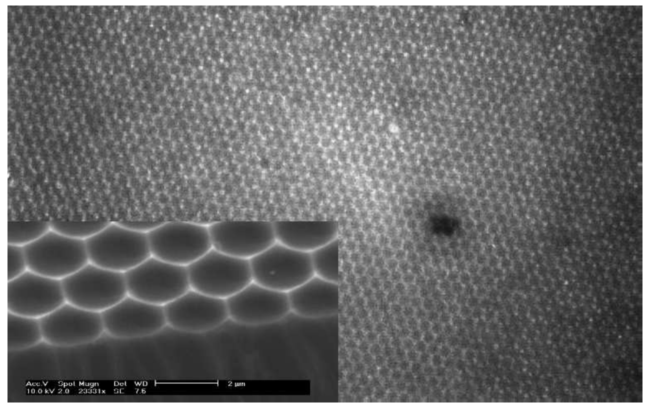

Fig. 1: Optical microscope image of the surface after etching a prestructured wafer – at all nucleation sites pores grew. Inset: SEM plain view (tilted) of unetched prestructuring masc.

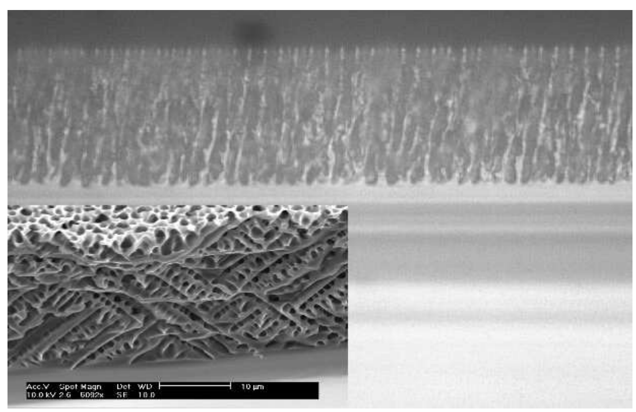

Fig. 2: Cross section of the wafer from Fig. 2 (optical microscope): Starting at the nucleation sites at the top of the (111) oriented wafer pores grow almost perpendicular into the wafer in contrast to the normally growing 113 pores on a (111) silicon substrate (see inset).

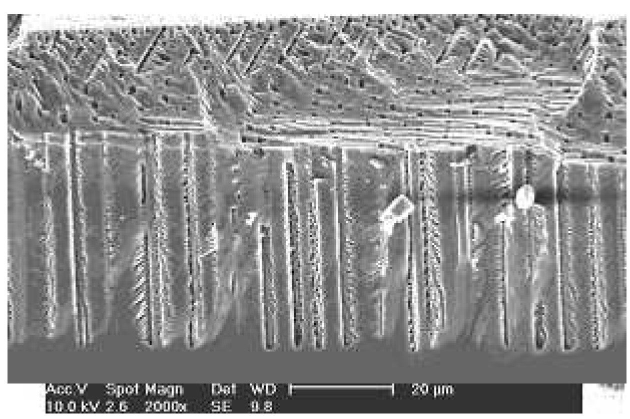

Fig. 3: Cross section (SEM) of (111) - oriented silicon etched in conducting salt containing organic electrolyte: In the upper part crystallographic pores have been formed at low voltages (1V). Increasing the potential to 3V, induces current line pores growing nearly perpendicular to the surface.