Particularities of Anodically Etched Pores in (100) Ge Substrates

S. Langa,[1,2] J. Carstensen,[1] S. Lölkes,[1] and I.M. Tiginyanu,[2] H.Föll,[1]

[1]*Faculty of Engineering, Christian-Albrechts University, 24143 Kiel, Germany;*

[2]*Laboratory of Low Dimensional Semiconductor Structures, Institute of Applied Physics, Technical University of Moldova, 2004 Chisinau, Moldova;*

In comparison to Si and III-V compounds, there is hardly any work on porous Ge at present; just about 4 to 5 papers can be found in the literature [1 - 4]. However, there are several reasons why porous Germanium should be of interest to the scientific community:

a. Ge has a larger dielectric constant than compared to Si or III-V compounds and thus is particularly suitable for photonic crystals applications;
b. The surface properties can be switched reversibly from hydrophobic to hydrophilic by changing the applied voltage and thus the potentially huge area of porous Ge could be functionalized and used for specific applications [5].
c. From the electrochemical pore formation point of view the properties of Ge are somewhere between Si and III-Vs - Ge is an non-polar elemental semiconductor like Si, however with an unstable oxide like the III-V compounds.

In the present paper the nucleation and growth of electrochemically obtained pores on (100) oriented n-Ge in different electrolytes is investigated and this is the first time that "good" macropores (with depth of more than 100 µm, see Figure 1a) were obtained in Ge. Pore nucleation is comparatively difficult, and it is found that on rough surfaces pore density increases as the current density increases, whereas on smooth surface it is vice versa, i.e. the pore density increases as the current density decreases.

These results imply that the pore nucleation depends strongly on the number of defects at the surface of the sample. At low defect density, domains of pores start to form, whereas at high defect density uniform porous structures can be obtained (see the inset in Figure 1a). This implies that prestructuring of pores, which is essential for many applications, should be quite easy on Ge.

The obtained macropores show strong anisotropic features with a cone like shape as they grow into the substrate following <100> directions (Figure 1b). This can be understood if the passivation of the pore walls in Ge is less pronounced as of Si or III-V compounds, but strongly anisotropic, i.e. the difference between the passivation "strength" of different crystallographic planes in Ge is larger than the corresponding differences in Si or III-Vs.

Figure 1c clearly shows the strong anisotropy of the pore walls and thus of the pore formation in Ge itself. Increasing the etch time the {100} facets disappear completely and are replaced by {110} walls (a feature not seen in any other porous semiconductor). This demonstrates that {110} planes are most stable against dissolution; probably because they are easier to passivate than {100} surfaces.

References

[1] H.C. Choi and J.M. Buriak, *Chem. Commun.* **17**, 1669 (2000).
[2] S. Miyazaki, K. Sakamoto, K. Shiba, and M. Hirose, *Thin Solid Films* **255**, 99 (1995).
[3] S. Bayliss, Q. Zhang, and P. Harris, *Appl. Surf. Sci* **102**, 390 (1996).
[4] S. Langa, M. Christophersen, J. Carstensen, I.M. Tiginyanu, and H. Föll, *Electrochem. Sol. State. Lett.*, submitted (2002).
[5] J.-N. Chazalviel, A. Belaidi, M. Safi, F. Maroun, B.H. Erne, and F. Ozanam, *Electrochem. Acta* **45**, 3205 (2000).

Acknowledgements

This work was supported by Deutsche Forschungsgemeinschaft (DFG) under the grants No. 436 MOL 113/2/0-1 and FO 258/4-1.

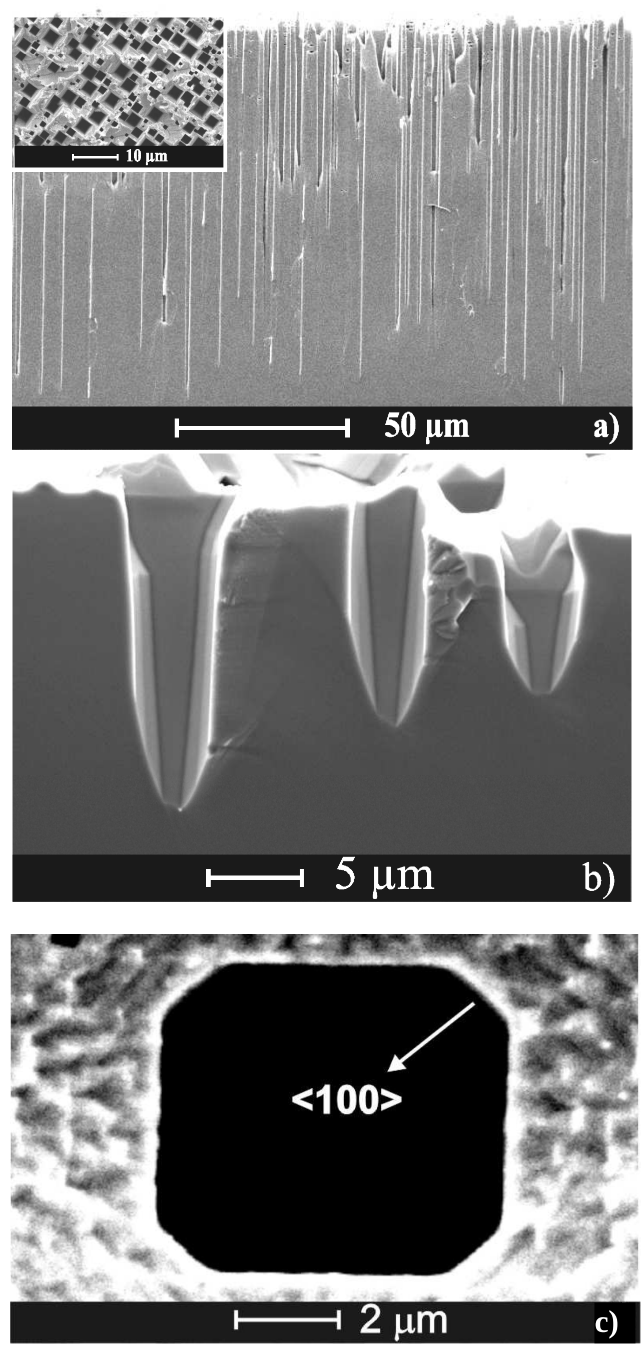

Figure 1. Pores in Ge; a) The cone like shape of the pores – cross section view; b) Uniform distribution of the pores on rough surfaces – plane view; c) In an intermediate state pore walls consist of {100} and {110} planes, increasing the etch time only the {110} planes remain.