Heavy Ion Induced Micropores in Glass as Nucleation Centers of Crystalline Silicon

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The generation of crystalline structures on amorphous substrates (glass) is of interest in several application fields, as in photovoltaic cells and micro system technique. Glass is useful because it is an electronic insulator, has a high transparency and low thermal conductivity and can be produced in large panes at a low-cost level. However, an epitactical growth of perfect crystals or crystalline films is not possible due to the lack of lattice structure of this non-crystalline material. A novel method of selective nucleation has been developed to achieve crystalline structures on glass substrate using metallic droplets on the surface acting as nucleation centers [1]. These droplets can be deposited in micropores which are produced by irradiation of the glass samples with heavy ions. At this process ion tracks are created where the network structure of the glass is locally destroyed.

We used a borosilicate glass (T_G < 600° C) as substrate material. For irradiation $^{208}Pb^{n+}$ (n=28) ions with energies of 11.4 MeV/nucleon were used applying a dose of $D = 3.3*10^5$ ions cm^{-2}.

In a subsequent chemical etch treatment of the material the ion traces are enlarged. As etching acid a mixture of HF (40 vol.%), HNO_3 (65 vol.%) and H_2O dest. in a 1:1:1 ratio was used. The etching time of irradiated samples was varied in four steps: 5 s, 20 s, 50 s and 80 s, respectively.

In this way, fields of micropores were generated in the glass surface. Scanning electron microscopy investigations (ZEISS DSM 962) reveal that the pores have a regular conical shape with smooth edges and walls. Depending on the etch time, pore diameters in the range 1,8 - 12 µm can be achieved (fig. 1). The aspect ratio of the pores was found to be 1.4 ± 0.2 (fig. 2). Microdroplets of low melting metals (gallium or indium) were deposited in these cavities by evaporation using the effect of coalescence due to the surface tension of liquid metal (fig. 3). In the next step, evaporated silicon is solved in the metal until droplets are saturated. Under the influence of a temperature gradient, nucleation occurs at the pits of the cavities. Solving additional vaporized silicon in the droplets, the growth of silicon crystallites inside of the cavities is continued. Thus, in each of the pores one silicon crystal is grown which can be observed when the solution is removed (fig. 4). Using this method, glass substrates with areas of more than 15 cm² can be covered regularly with silicon crytallites of about 1 µm size and mean distances of 20 µm.

[1] T. Boeck, Th. Teubner, K. Schmidt, P.-M. Wilde: J. Crystal Growth 198/199 (1999) 420-424.

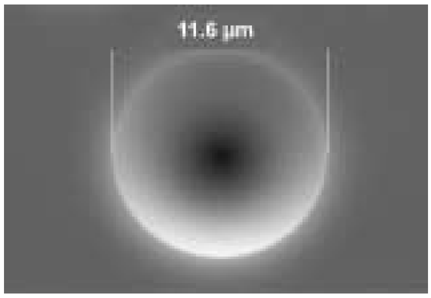

Fig. 1: SEM image of an etched ion track in the glass surface. The pore has a smooth wall and regular edge structure.

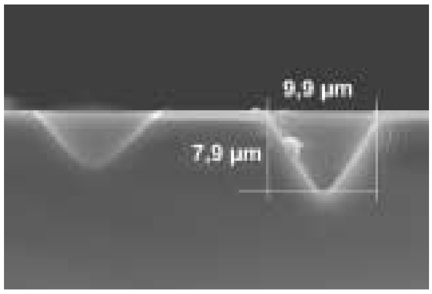

Fig. 2: Cross section of pores in glass with regular cone geometry. The measured aspect ratio is 1.25.

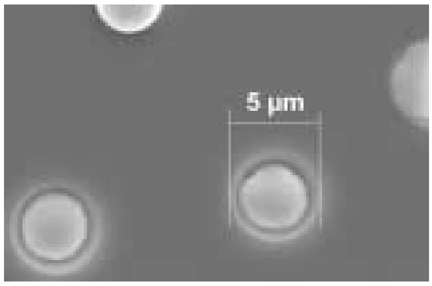

Fig. 3: SEM image of metallic microdroplets which are deposited in the pores.

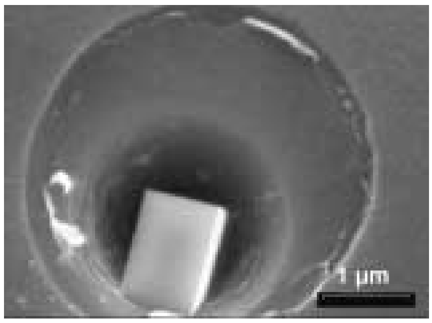

Fig. 4: A silicon single crystal is grown in the microcavity. The circular contour arises from the removed amorphous silicon.