Synchrotron X-ray topography study of silicon-on-insulator wafers with cavities

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The samples studied are test structures especially made for an investigation of strain fields created by oxide at the oxide - silicon single crystal interfaces. In the four wafers investigated there are cavities etched in the substrate. The cavities have a width of 50, 200, 500 and 800 µm. The thickness of the thinned topmost silicon wafer bonded to the substrate is 4.1, 6.1, 10.0 and 19.9 µm, respectively. The silicon oxide in between has a thickness of 1 µm in each sample.

Synchrotron x-ray topographs were made at the HASYLAB-DESY F1 topography station in transmission and back-reflection geometries on high-resolution VRP-M films from Slavic with sample-to-film distances of 60 mm. The test structures of the samples were on the film side. The wafer was tilted 16 degrees about the horizontal [110]-axis in order to record also the small-index 220 reflection from the lattice planes perpendicular to the wafer (001) surface. The x-ray topographs were magnified with an optical microscope equipped with a digital camera.

Figures 1, 2 and 3 show transmission topographs of a silicon-on-insulator sample. The rows of square and round cavities are the prominent features of the diffraction image. Two types of strain fields are observed. The less sharp rather broad lines are interpreted as a result of strain produced by oxide at the square and round cavity edges of the substrate. The contrast follows the diffraction vector.

Figure 1. 220 transmission topograph of a silicon-on-insulator sample with cavities.

The other strain field is observed as very narrow and sharp black strings overlapping the broad oxide edge images of the substrate. The string like images are symmetrical figures and their contrast follows the diffraction vector in the same way as the broad lines do. The strings are interpreted as images resulting from the strain between the oxide layer and the topmost thin silicon wafer attached to the substrate. The size of the string image seems to be related to the magnitude of the strain and the shape of the cavity.
Figure 2. 040 transmission topograph of a silicon-on-insulator sample with cavities.

Figure 3: 400 transmission topograph of a silicon-on-insulator sample with cavities.

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