ESRF	**Experiment title:** **Strain and surface damage in ultra-thin wafers**	**Experiment number**: ME-304
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Shifts: 9	**Local contact(s)**: Petra Pernot	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):
Tilo Baumbach[+]
Christof Landesberger[§]
*Petr Mikulík[+]
*Petra Pernot[+#]
*Dušan Korytár[+]
*Lukas Helfen[+#]
[+] Fraunhofer Institut IZFP, Krügerstrasse 22, D-01326 Dresden, Germany
[§] Fraunhofer Institut IZM, Hansastrasse 27d, D-80686 Münich, Germany
[#] ESRF Grenoble, France

Report:

The aim of this study was to detect surface damage, generated by surface microgrinding of silicon wafers and removed in subsequent technological steps, by means of X-ray techniques. A series of thick and ultrathin Si wafers prepared for this purpose has been studied by white beam and monochromatic beam Laue and Bragg projection and section topographic techniques at beamline ID 19.

White beam topography has been shown to be able to visualize surface damage after grinding. However, it was not sensitive enough to detect damage after any subsequent etching or polishing step. For this purpose, two monochromatic techniques have been confirmed as the most suitable ones:

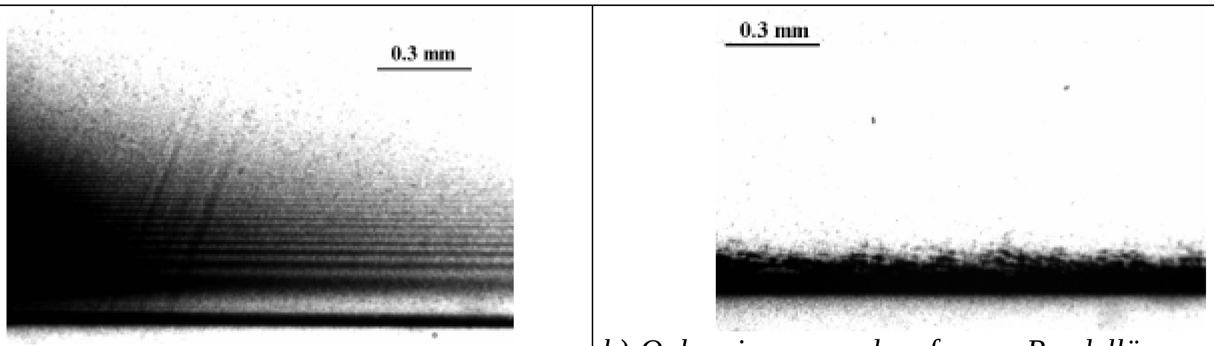
a) X-ray monochromatic section topography in Bragg case with its high sensitivity to (submicrometer) defects through the visibility of Pendellösung fringes. For this technique, vertical scattering plane has been used. A two-crystal Si (111,111) monochromator was adjusted to select 20 keV monochromatic beam. The width of horizontal slit was set to 15 μm. Si (001) wafers were adjusted to grazing emergence (115) diffraction. The Bragg diffraction was taken from the interested processed side. Because of tedious adjustment procedure in the setup used, the tilt optimization of the sample and two monochromator crystals has not been done precisely, but sufficiently enough to obtain Pendellösung fringes at some parts of the topographs. Fig. 1 shows section topographs from SML 43 (thick) wafers with different surface finishes.

b) High resolution monochromatic double crystal topography with its high sensitivity to strain and diffuse scattering at the tails of rocking curves. A vertical silicon double crystal (111,111) monochromator was used for tuning 20 keV or 12.4 keV energy of the X-ray beam. Specimen wafers were set into the Bragg position in horizontal or vertical scattering plane. Symmetrical diffraction (004) at 10 keV or at 20 keV and the asymmetrical (066) at 12.4 keV have been used. Due to some dispersion in the experimental setup various points on the wafer surface have a contrast corresponding to various positions on rocking curve. This way, some low contrast localized defects (LCD) could be visualized in ground and etched wafers.

Two main results related to grinding damage and its removal by spin etching have been obtained during this study:

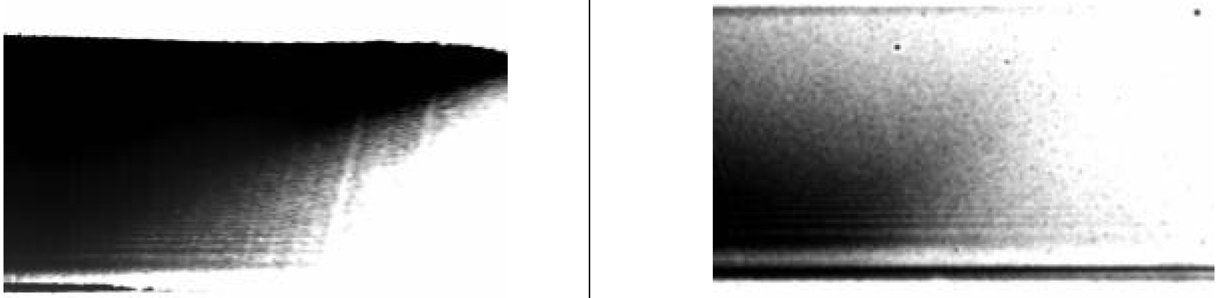
1. Etching-off or polishing-off (CMP) of only 5 micron thick surface layer after grinding is sufficient to remove the surface grinding damage significantly so that the Pendellösung fringes are restored to some degree. However, full restoration of the visibility of fringes has not been observed even after 46 micron etching and 5 micrometer polishing (Fig. 1).

2. Low density (<1000 cm^{-2}) of larger (<20–80 micron size) low contrast defects (LCD) remain even after etching-off 20 microns of surface layer (Fig. 2). They were not observed in reference wafers.



a) Untreated (CMP) monitor wafer, about 20 fringes visible under the optical microscope.

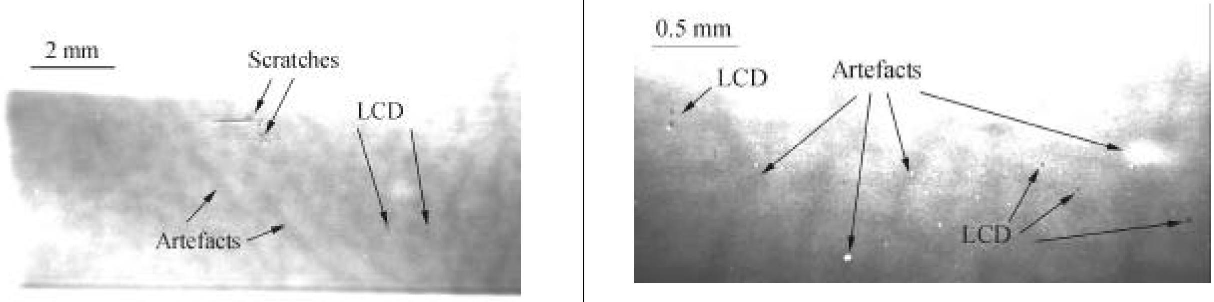
b) Only microground wafer, no Pendellösung fringes are visible.



c) Ground + 4 mm polished (CMP), 9 fringes visible.

d) Ground, 46 mm etched, 4 mm polished, 8 fringes visible.

Fig. 1. Monochromatic (20 keV) Bragg (511) section topography of Si wafers with different surface finishes.



a) Si specimen ground to 100 mm and etched 20 mm.

b) Thick Si specimen ground, 5 mm etched.

Fig. 2. Double crystal topography (10 keV, (004) vertical Bragg diffraction) of thin and thick Si wafers. In addition to LCD some artefacts (broad darker bands from beryllium window and white spots from dust particles) are seen, too.