Synthetic diamond, ruby and cubic zircon dioxide: complex layer structures and surface modifications due to synthesis, cutting, grinding and polishing

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Synthetic diamond, ruby and cubic zircon dioxide are materials with interesting physical properties and have wide-ranging impacts in e.g. electronics as well as machining and cutting tools. These properties may change with respect to the synthesis, as in the case of diamond, and due to post-syntheses treatments like cutting, grinding and polishing, as in the case of ruby and cubic zircon oxide.

We used Raman and infrared spectroscopy, laser-induced luminescence spectroscopy, X-ray single crystal and powder diffraction, electron microprobe and atomic force microscopy to investigate various samples. Diamond plates with thickness > 1 mm and several mm diameters could be synthesized using chemical vapour deposition (CVD). Several carbon modifications starting from amorphous carbon up to diamond single crystals with properties corresponding to perfect natural diamonds from South Africa could be identified. Nitrogen contents of the synthetic diamonds are highly variable from virtually nitrogen-free up to several thousands of ppm. Nitrogen and silicon related defects were observed in some samples, as well as Raman band splitting and shifting of certain bands from the surface up to 5μm depth in the sample. This is attributed to the occurrence of defect-induced, hexagonal micro-phases and anisotropic stress along grain boundaries (Rossi et al. 1999).

Verneuil-grown ruby samples and Y-stabilized zircon dioxide were manually and automatically grinded and polished by diamond powders and silicon dioxide sizing from 40 down to 1 μm. The ruby samples were cut parallel and perpendicular to their crystallographic c-axis. Both wavelength and full width at half maximum of the laser-induced ruby luminescence modes shifted from the sample surface to 1 μm depth in the range of 694.253-694.276 nm and 0.55-0.54, respectively. These changes depend upon grain size of the grinding powder as well as crystallographic orientation of the polished surface. This is probably related to an increased appearance of defects like dislocations and stacking faults in the uppermost layers of the ruby. Raman mappings of scratches in the polished surfaces show the same trends. Similar observations were made for grinded and polished silicon wafers (Chen et al. 2000).

In summary, our investigations suggest nanometer scaled, complex surface modifications and structural changes depending on depth of both synthetic diamond and ruby and cubic zircondioxide materials, which are related to synthesis, cutting, grinding and polishing, respectively. In the next step of our investigations, high-resolution TEM studies will be applied to prove this hypothesis.

References

Rossi MC, Salvatori S, Galluzzi F (1999) Surface Distribution of Stress State and Diamond Phases in [100] Oriented Diamond Films. Phys Stat Solidi A 172: 97-103

Chen LQ, Zhang X, Zhang TY (2000) Micro-Raman spectral analysis of the subsurface damage layer in machined silicon wafers. J Mater Res 15: 1441-1444

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