

Ablation and irreversible material changes of single-crystalline silicon irradiated with ultrashort pulsed laser radiation

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Irradiating single-crystalline silicon with ultrashort pulsed laser radiation above a material-specific threshold causes irreversible modifications, beginning with alterations in crystallinity and progressing to ablation. This work focuses on analyzing these transformations in <111>-oriented single-crystalline silicon as a function of the applied laser fluence (40 fs, 800 nm). The irreversible changes resulting from the interaction between laser radiation and the material were identified through measurements of the spatially and spectrally resolved refractive index using ex-situ ellipsometry and the surface topography in the irradiated regions were performed using scanning electron microscopy analyses, confocal laser scanning microscopy, and atomic force microscopy. Further information on the depth of thermally induced material modifications was obtained through subsequent wet chemical etching (Figure 1). Together with the measured dynamics of the optical properties by pump-probe imaging reflectometry and interferometry, all approaches provide a more detailed and accurate characterization of the involved physical processes upon ultrashort pulsed laser irradiation.

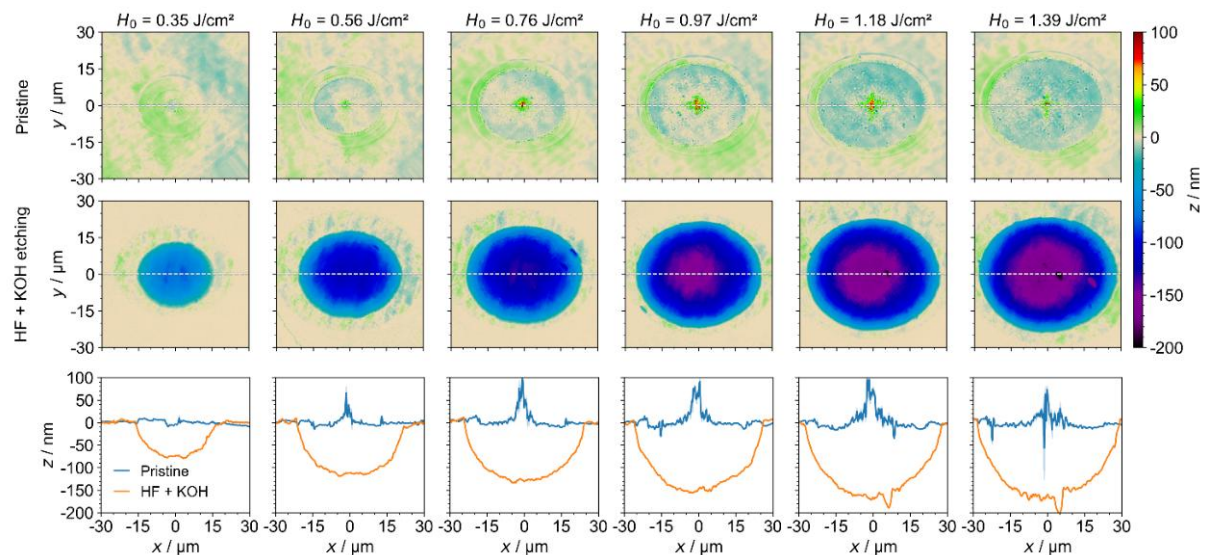


Figure 1: Irreversible material changes resulting from the single pulse irradiation with ultrashort-pulse laser radiation (top row: topography after single pulse irradiation; middle row: topography after wet chemical etching; bottom row: comparative cross-section in the center of the ablated structures before and after wet chemical etching).

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