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J Environ Geol. | Volume 3
ISSN: 2591-7641

Polarized Raman scattering of crystalline semiconductors cut off-axis

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A unique approach to polarized laser Raman spectroscopy is introduced to investigate the structure and crystallinity of Si wafers based on measured intensity profile and Raman intensity theoretical model. The orientation of the crystal in our model is defined by two angles, the angle between (001) crystal axis and the lab z-axis, and the angle of rotation of the crystallographic xy plane about the crystal's z-axes. Raman selection rules for a given crystal symmetry govern the interaction between the incident polarized laser and analyzed output. The scattered light intensity depends on the laser wavelength, the cross-sectional area from which light is collected, the penetration depth of the laser, and the crystal orientation for specific experimental geometry. An intensity map is generated when wafers of different geometry are rotated about the lab z-axis that varies the angle between the fixed incident light polarization and the crystallographic axes. Calculated Raman intensity for LO- and TO-modes for various crystallographic orientations when the polarizer and analyzer are both horizontal (HH) and when they are perpendicular (HV) are presented. By increasing the crystal's tilt Θ from crystal's +z-axis to –z-axis and rotating the crystal about the crystal z-axes for Θ from 0-45o a set of predicted profiles for various Si sample cuts are generated. Calculated profiles for the combination of the LO and TO modes for (100), (110) and (111) silicon are in excellent agreement with normalized experimental data published for these geometries. The changes in our Raman intensity profile provides an effective approach in determining the degree of off-axis cut for single crystal Si. Similar studies using our unique polarized Raman scattering applied to GaAs is underway. Our unique approach could be used as an alternate viable method to establish crystallographic orientation for cut off-axis single crystalline semiconductors.