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Infrared dielectric anisotropy and phonon modes of sapphire

Abstract References Citing Articles (123)
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Spectroscopic ellipsometry in the infrared spectral range is used for comprehensive analysis of the anisotropic dielectric response of sapphire. We determine the ordinary and extraordinary infrared complex dielectric functions as well as all infrared-active phonon modes of single crystal α-Al_2O_3 for wavelengths from 3 to 30 μm. Data were acquired from high-symmetry orientations of *a*-plane and *c*-plane surfaces cut from bulk crystals. A simple classification scheme is developed, which allows identification of the total reflection bands for *p*- and *s*-polarized light in anisotropic materials with multiple phonon branches. We employ a factorized form of the dielectric function for superior best-fit calculation of the infrared ellipsometry spectra adjusting frequencies and damping parameters of the transverse and longitudinal phonon modes with A_{2u} and E_u symmetry separately. A generalized Lowndes condition for the damping parameters is derived and found satisfied for the A_{2u} and E_u branches. Excellent agreement with phonon mode literature values is obtained, and improper use of selection rules reported previously for calculation of the sapphire dielectric functions is revised [Harman, Ninomiya, and Adachi, J. Appl. Phys. **76**, 8032 (1994)]. The dielectric function model will become useful for infrared ellipsometry investigation of multiple-layer structures grown on α-Al_2O_3 substrates such as group-III nitride heterostructures.

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