

Optical Characterization of Calcium Fluoride and Grey Tin Using Spectroscopic Ellipsometry

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In this work we present an optical study of two materials: calcium fluoride and grey tin. We use spectroscopic ellipsometry to determine the optical constants for both materials, but the interpretations of data are different because calcium fluoride is an insulator with a wide transparency range and grey tin is a semimetal with unique electronic properties. We use x-ray diffraction for structural characterization of the samples in order to support the analysis of ellipsometry data by verifying the surface orientation (for calcium fluoride) and layer thickness (for grey tin).

We refine the optical constants of calcium fluoride from 0.14 to 40 μm for two commercially available bulk substrates with surface orientations (100) and (111). We compare our results with literature values from *The Handbook of Optical Constants of Solids II* [1] and find that there is excellent agreement, especially in the infrared region where the infrared active phonon modes are identified. Towards the absorption band edge of calcium fluoride, we find that the onset of absorption is slightly lower than in the literature [1] and attribute the difference to the presence of defects in the lattice.

For grey tin we measure the temperature dependent dielectric function using Fourier Transform Infrared (FTIR) ellipsometry from 300 K to 10 K and observe the $\bar{\Gamma}E_0$ transition for two grey tin epitaxial layers grown by Molecular Beam Epitaxy (MBE) on InSb substrates with different interface preparations. The substrate interface preparation influences the number of donor or acceptor ions in the grey tin lattice, and we observe a change in the oscillator strength of the $\bar{\Gamma}E_0$ transition. We apply the Thomas-Reiche-Kuhn f-sum rule [2] to the $\bar{\Gamma}E_0$ absorption peak and calculate the carrier density as a function of temperature. We compare carrier densities for grey tin samples that are considered intrinsic, p-type, and n-type doped. We find that the oscillator strength of the $\bar{\Gamma}E_0$ peak is strongly dependent on the sample preparation that can change the type of doping in the grey tin layer.

[1] D. F. Bezuidenhout, *Handbook of Optical Constants of Solids II*, Academic Press, San Diego, 1997, p. 815.

[2] M. Altarelli et al., *Superconvergence and Sum Rules for the Optical Constants*, Phys. Rev. B **6** (1972), p. 4502.