Overview of Optical Metrology of Advanced Semiconductor Materials

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ABSTRACT

As novel materials are being investigated for semiconductor applications, it becomes imperative to advance the characterization techniques to meet the metrology requirements for these next generation materials. Spectroscopic ellipsometry (SE) is a rapid optical metrology technique capable of characterizing advanced materials. In this overview, SE was utilized to measure various other properties beyond conventional parameters (optical constants and thickness). In the case of very thin metal films, the correlation between thickness dependent optical properties and the free electron relaxation time is traced to the change in grain size. Low-κ dielectric materials were characterized to extract the chemical (molecular bond vibration and carbon content), porous (pore volume fraction and pore size), and mechanical (coefficient of thermal expansion and Young's modulus) properties. SE was also employed to measure the bandgap of high-κ dielectric thin films and the glass transition temperature of EUV photoresists and under layers. The percentage of curing in adhesive bonding layers used in 3D interconnects and the stress in strain engineered III-nitride thin films were measured via infrared SE. SE is also an excellent method of measuring thin Silicon on Insulator materials. The shift in transition energies of the critical points in extremely thin silicon-on-insulators (ETSOI) were measured using reciprocal analysis of the optical response. This talk will also describe other optical methods that are complementary to SE. Photoreflectance can measure the energy of the E1 critical point and thus strain in Si and SiGe and changes in band structure while low temperature photoluminescence can measure changes in the band gap of nanomaterials and identify the electron-hole (e-h) phase due to 2D quantum confinement.

Keywords: Ellipsometry, photoluminescence, photoreflectance.

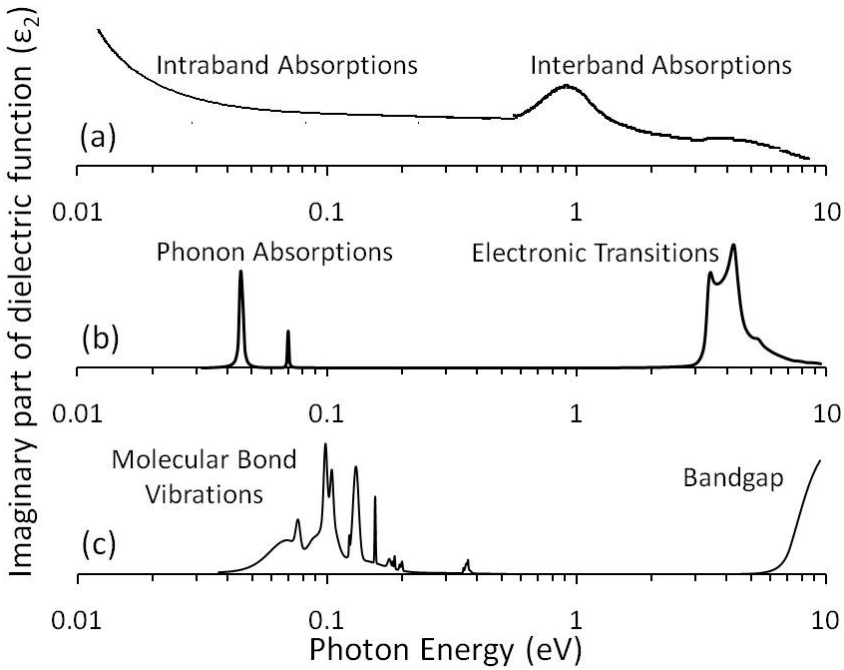

FIGURE 1. Imaginary part of dielectric function (ε_2) of (a) metals, (b) semiconductors and (c) dielectrics