

Influence of Film Thickness and Interface Scattering on the Electron Thermoreflectance Response in Metals During Intra- and Interband Excitations

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Ultrashort pulsed laser are an effective tools for use in a wide array of nanoapplications, ranging from precise machining of nanomaterials, to deposition of nanocomposites, to diagnostics for observations of transport properties on atomistic time and length scales. One critical caveat of these applications is predicting and controlling the temperature of the materials after the absorbed laser pulse. At relatively low absorbed laser powers, the temperature can be determined from the reflected energy from the laser pulse off the sample surface as the reflectivity and the temperature change are linearly related. However, as laser pulses become more powerful, thereby inducing large temperature changes, and as materials continue to decrease in characteristic lengths, thereby causing substrate interference affecting the absorbed energy, the determination of the temperature from reflectance becomes more complicated than the traditionally assumed linear relation. In this work, a reflectance model is developed that accounts for large temperature fluctuations in thin film metals by utilizing the temperature dependencies of the intraband (“free” electron) and interband (“bound” electron) dielectric functions and multiple reflection theory. The temperature dependencies of electron-electron, electron-phonon, and electron-substrate scattering are exploited and the change in reflectance as a function of these various scattering events is studied in the case of both intraband and interband excitations. This thermoreflectance model is compared to thermoreflectance data on thin Au films.

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