Development of a System for Measuring Thermal Properties Based on Wavelength-Tunable Time-Domain Thermoreflectance

Abstract:

Time-domain thermoreflectance (TDTR) technique has been widely used to measure thermal properties such as thermal conductivity and interface thermal resistance. In traditional TDTR experiments, the probe is usually a laser beam from a commercial Ti:sapphire laser at wavelength near 800 nm and Al is chosen as the corresponding thermal transducer due to its high thermoreflectance signal near 800 nm. However, this “800 nm + Al” combination is limited by the oxidation and low melting temperature of Al. With the advance of laser technology, new laser sources with different wavelengths are accessible. Therefore, TDTR experiments could be performed more flexibly by extended selection of metal thermal transducers cooperating with various laser wavelengths to accommodate various TDTR operating conditions. To facilitate the TDTR measurement, the thermoreflectance of metal thermal transducers should be well understood. In our work, we perform both theoretical and experimental studies on the thermoreflectance spectrum of metals. We use Au and Cu to validate our approach and demonstrate good agreement between the theory and the experiment. The proposed study not only elucidates the fundamental optical response of metal transducers, but also provides a general guideline for choosing the appropriate probe wavelength to optimize the TDTR signal for a given metal thermal transducer, which is useful for a variety of thermal property measurements.