Ultra-Fast Heat Diffusion Measurement —Application to Thermophysical Properties of Thin Films and Interfaces

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Tuning the thermal energy transports in thin films, nanoscale structures and interfaces become a critical issue for optimizing the performance of current electronics, thermal energy-conversions, heat storages and heat dissipation devices. A pulsed light heating thermoreflectance (generally called time-domain thermoreflectance; TDTR) is a powerful and indispensable tool to explore their heat transport mechanisms. The TDTR is basically similar to the laser-flash method that for the thermal diffusivity measurement for the disk-shaped samples. Instead of the radiation thermo-sensor in the laser-flash, the TDTR utilizes small reflectivity change of the sample or a metal transducer layer, which enables us to observe ultra-fast change of the temperature. Our TDTR apparatus (Fig.1) equips some unique features. Two separate and synchronized femtosecond lasers for pump and probe allow us to observe wide range of heat diffusion (~50 ns) with a ps time resolution. The most of laser sources and optical controls are fully optical fiber constructions. The optical sensor is free from the noise coming from the pump laser because the wavelength of the pump (1.5 μm) is far from sensitivity of the silicon-photodiode. Here we show some recent topics utilizing our TDTR, such as tuning thermal conductivity by grain boundaries(diamond, ZnO) and van der waals interface(MoO_3), heat flow across the atomic layers, and enhancement of heat transfer at liquid-solid interfaces.

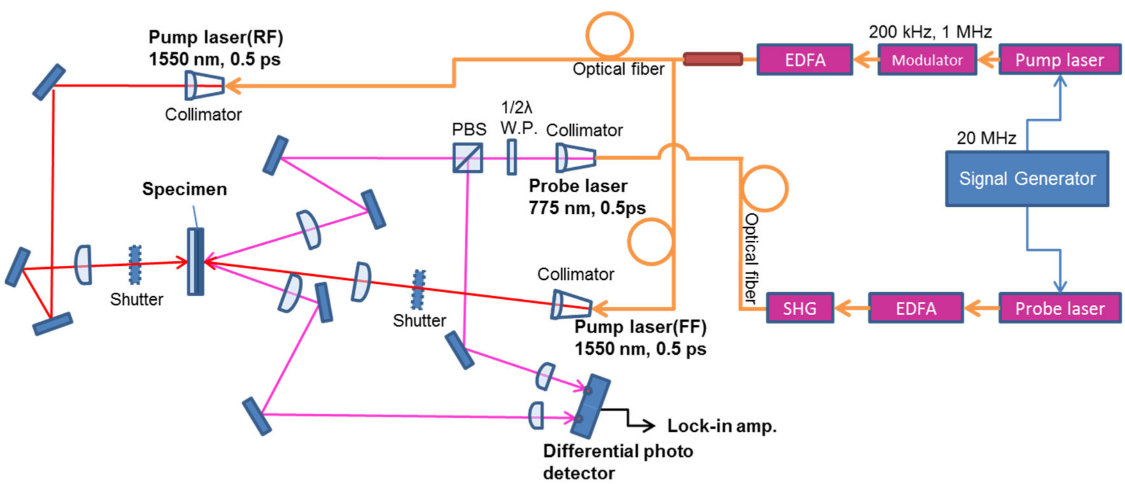

Figure 1 Pulsed light heating thermoreflectance apparatus developed in AIST, Japan.