Investigating a Steady-State Thermoreflectance and 3ω Method for the Thermal Characterization of Microwave Atom Chips

Paul Kelemen | Dr. Seth Aubin | William & Mary Ultra-Cold AMO Laboratory

Physicists use microwave atom chips to "trap" atoms for cold-atom experiments. To do this, these chips can require up to fifty Watts of microwave power to pass through its copper traces. At such high-power applications, trace overheating can damage or destroy the chip. To mitigate this risk, microwave atom chips consist of a layer of thick-film aluminum oxynitride (ALON), which dissipates heat away from the traces. These thick-films are called microwave heatsinks, and their performance is determined by AlON's thermal conductivity, which is not well-known. We investigate two methods for measuring the thermal conductivity of thick-film AlON microwave heatsinks using a steady-state thermoreflectance (SSTR) and 3ω technique. While the SSTR method poses several challenges, the 3ω method shows great promise for practical application and is being developed further for a test on a sapphire microwave heatsink. For the SSTR method, we present the thermoreflectance effect in thick-film aluminum and calculate its thermoreflectance coefficient of $\beta \approx 0.010\ \mathrm{K}^{-1}$. For the 3ω method, we present the 3ω effect in an experimental 200 Ω axial resistor setup ranging from 0.05 to 0.105 Amps with a peak amplitude of 7.500 mV ± 0.257 mV.