

Finite Element Simulation for Thermal Effusivity Measurements in a Local Area by a Thermal Microscope

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We have been studying a thermal effusivity distribution measurement method based on a periodical heating and thermorefectance technique, with a *thermal microscope* [1-4], to measure the thermal effusivity of a thin film of a functionally graded material. The front heating front detection configuration is applied with the thermal microscope. The thermal effusivity in the depth direction is estimated from the phase difference between the modulation signal of the heating laser and the thermorefectance signal. An irradiation area of the heating laser beam on the sample surface, which was observed by a CCD camera, was about 15 ~ 30 μm , and that of the probe laser beam was about 6 ~ 10 μm . The minimum resolution of the thermal effusivity by the thermal microscope was estimated to be 2 % in the case of YBCO thin film [3]. Hatori *et al.* [4] has discussed the applicability of the one-dimensional (1D) conduction model [1] to the microscope in high frequencies, where thermal diffusion length is smaller than the spot diameter. When the thermal diffusion length becomes larger than the spot diameter of the heating laser and the probe laser at lower modulation frequencies, a three-dimensional (3D) conduction model must be considered, instead of the 1D model. The experimental results using the 3D model were simulated by a finite element method in 3D model. The measured phase lag agreed well with the simulated value, if we assume that the spot diameter of the heating laser is 12 μm ; at the full-width in the Gauss distribution for the simulation, even the thermal diffusion length becomes large.

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