Thermal Conductivity Measurements on CVD Diamond Using Graphitic Microheaters Prepared by Laser Scribing

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While diamond is a good insulator, graphite is an electrical conductor. Therefore, graphitic lines in diamond can be used as embedded microheaters. We prepared those graphitic resistors in various shapes by Nd:YAG laser scribing, i.e. by converting the diamond surface into graphite. These microheaters were used to establish a well defined heat flux through CVD diamond samples. By analyzing the resulting temperature variations, the thermal conductivity or diffusivity was derived. In this paper several measuring techniques based on these microheaters are described and compared.

The first technique is a steady-state heated-bar technique which uses a graphitic microheater located at one edge of the diamond bar to produce a linear heat flow through the sample. The thermal conductivity is obtained by measuring the resulting temperature gradient with an array of bonded thermocouples. This technique allows precise temperature resolved thermal conductivity measurements from liquid nitrogen temperatures up to several hundred degrees Kelvin.

For other methods microheaters are applied to generate a heat wave by pulsed electrical heating. Two different sample geometries, bar shaped and circular, were investigated. In the first case, a line shaped microheater is located in the center of the diamond sample. The time dependence of the heat wave is measured optically using an IR detector at the backside of the sample for various positions perpendicular to the microheater. In the second case, the microheater is produced at the rim of a circular diamond plate. The electric pulse generates a converging thermal wave. Its time dependence is measured at various radial positions. For both geometries, the thermal diffusivity can easily be obtained by comparing the phase of the heat wave with simulations.