Nondestructive Testing and Determination of Thermal Parameters in Thin Films and Microcomponents with Photothermal Methods

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Photothermal methods are powerful tools for the determination of thermal parameters and also testing of materials on the scale of several micrometers. These methods can be used to measure heat flow parameters but also to detect subsurface defects in thin films and microcomponents.

The principle of photothermal methods is based on the generation of thermal waves - i.e. temperature oscillations which are periodical in space and time - by intensity modulated light at the surface of a sample and the detection of the run time behavior of these thermal waves. The penetration depth of the thermal waves depends on the thermal conductivity and the modulation frequency of the light intensity. In the low frequency range the penetration depth is relatively large while at high frequencies it is restricted to surface near regions of the sample. By scanning the modulation frequency over an appropriate range thermal depth profiles can be measured. This specific option of photothermal methods allows for the inspection of subsurface regions since defects which are located beneath the surface of a sample can be "seen" which can not be detected by optical measurement techniques. Additionally, photothermal measurements can be performed with spatial resolution of the order of micrometers by focusing the light (laser beam) since only the heated area contributes to the measured signal.

Application field of this method is the nondestructive testing in thin films, multilayer systems and microcomponents. Thermal parameters like the thermal conductivity can be determined, but also defects like cracks, pores or delaminations in film - substrate systems and differences in adhesion strength can be detected. In the multilayer system Ti-TiO_x-PMMA the thermal contact resistance and the adhesion strength has been determined by depth profiling which gives information about the influence of a coupling agent. Effects of micromachining have been observed in LIGA-microcomponents and also defects in movable microstructures exposed to cyclic mechanical loading. Within this paper further results of photothermal measurements on layered systems, LIGA-microstructures and movable microcomponents will be presented. The application of this measurement technique as a kind of quality testing tool in microsystems will be discussed.