Measuring Thermophysical Properties in Thin Films and Microcomponents with Photothermal Methods

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Measurement techniques for nondestructive testing and quantitative determination of thermal properties are gaining importance in thin film processing and microsystem technology. Photothermal methods can be used to determine heat transport properties like the thermal conductivity in thin films but also with spatial resolution in microcomponents. This measurement technique can also be used for nondestructive testing with high spatial resolution and flexibility in its detection schemes. One of the main advantages of this method can be attributed to the so called depth profiling option. Using the option of thermal depth profiling, gradients of thermal properties as well as subsurface flaws can be detected which cannot be observed by optical inspection techniques.

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 waves. The amplitude of a thermal wave is strongly damped, and its penetration depth is therefore limited depending on the thermal conductivity and the modulation frequency of the light intensity. At low frequencies the penetration depth is relatively large while at high frequencies it is restricted to surface-near regions of the sample. This specific option of photothermal methods allows for the determination of thermal properties in layered systems and also of for the nondestructive inspection of subsurface regions. 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.

An application field of this method is the measurement of thermophysical properties and 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. The results of the measurements of the thermal conductivity in different thin film-substrate systems will be presented and discussed. In layered and multilayer systems the thermal contact resistance and the related adhesion strength has been determined by depth profiling. A photothermal scanning technique has been used to detect subsurface defects in microcomponents in a nondestructive way.