

Simultaneous Thermal and Optical Depth Profiling of Functionally Graded Materials

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During the last decade modulated photothermal techniques with plane illumination have been used to retrieve the thermal conductivity depth profile of hardened steels. Recovering the internal conductivity from surface temperature data is a severely ill-posed non linear inverse problem. Accordingly, suitable inversion procedures have been developed in order to obtain reliable solutions, as neural networks, genetic algorithms and stabilized least-square fittings. In this work we deal with the simultaneous reconstruction of the thermal conductivity (K) and optical absorption coefficient (α) depth profiles of partially cured resins and eventually functionally graded materials; i.e. continuous changes in the composition or microstructure result in gradients in mechanical strength, thermal conductivity and optical absorptivity. First, to calculate the surface temperature of such a material we have extended the thermal quadrupole method to semitransparent layered materials. In this way, the frequency dependence of the surface temperature corresponding to continuously varying K and α could be simulated by using a high number of homogeneous layers. However, this number of layers can be reduced to 20-30 without lack of accuracy by using layers of not constant thickness: thinner as they approach to the surface. Then, we have shown numerically that K and α are degenerate if the number of layers ≥ 3 , when using plane illumination as excitation source. In order to overcome this degeneracy we propose the use of focused illumination instead of extended excitation in order to take advantage of the additional information coming from the lateral heat diffusion. We analyze whether combining frequency scans and radial scans of the surface temperature helps breaking the degeneracy of K and α .

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