Nanoscale Surface Displacement Detection by Thermal Mirror Technique

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One of the most ordinary effects observed using tightly focused laser beams on solid samples is the surface displacement or deformation. The basic principle, employed in almost all techniques based on this effect, consists of detecting the laser-induced surface deformation of a solid sample. The deformation can be detected by deflection or focusing/defocusing of the probe beam reflected from the sample surface. The time-resolved Thermal Mirror (TM) method has been introduced under cw Gaussian laser excitation. Thermal diffusivity and thermo-optical properties were quantitatively determined for semi-transparent and opaque solids. The TM effect arises from a local surface deformation of the sample, created by the temperature rise produced by absorbance of an excitation laser beam. Another Gaussian beam, almost collinearly arranged with the excitation beam, impinges the excited area and the centre point of the spot of its reflection is probed in the far field region. The TM modeling proposes the sample as a semi-infinite medium and the thermoelastic equations are solved accordingly. Under the semi-infinite approximation, the sample is treated as an infinite medium along the z axis. Basically, it is assumed that the thickness is large enough that the displacement vector at the surface is not affected by the induced deformation within the sample thickness. However, the agreement between this approximation and the experimental data depends on the thermo-optical and mechanical properties of the sample and cannot be determined using the semi-infinite model. Here we show that the size effect should be considered for thin samples. We present a theoretical and experimental analysis of the surface deformation in a finite-size model. We used the analytical solutions to analyze experiments performed in optical glasses.