Tomographic Reconstruction of Photothermally Induced Picosecond Strain Pulses in a Transparent Substrate

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Laser picosecond acoustics can be used to probe in interior of materials nondestructively. In conventional set-ups, pump light pulses from an ultrashort pulsed laser photothermally generate longitudinal acoustic strain pulses in opaque thin films in the frequency range ~10-1000 GHz. Delayed probe light pulses detect any strain pulses that return to the surface. However, no existing method can measure picosecond acoustic pulses continuously during propagation. We presented a method for visualizing plane picosecond acoustic waves propagating in a transparent medium using ultrashort optical pulses. The principle is as follows: longitudinal acoustic strain pulses are photothermally generated in a thin metal film coating the transparent medium. The strain pulses transmitted to the transparent medium induce a weak modification of the refractive index distribution through the photoelastic effect. As a consequence the optical reflectivity of this sample is perturbed when probed by light pulses incident from the transparent medium side. An integral relationship is known to relate the change in the optical reflectivity to the perturbed refractive index field inside the sample. To visualize the spatial acoustic strain distribution, we solve the inverse problem of computing the strain field from the observed perturbation in the angular reflectivity spectrum using *s*-polarized probe light. We can then effectively visualize the propagation of the acoustic strain wave by repeating the inversion process for a sequence of delay times between the optical pump and probe pulses. We demonstrate this method with a BK7 glass hemisphere coated on its flat face with a gold film. We measure the time-resolved reflectivity changes for optical incidence angles 15-75 degrees, and then reconstruct the propagating longitudinal acoustic pulse in the glass.