 ICCES, vol.20, no.1, pp.3-3

Impulsive fracture by nonlinear and nondestructive evaluation of these cracks by linear surface acoustic waves

Peter Hess, Alexey M. Lomonosov, AndrAC Moura, and Peter V. Grigoriev

Summary

Crack generation by the steep shock fronts of laser-induced nonlinear surface acoustic wave (SAW) pulses and their nondestructive evaluation (NDE) by short linear SAW pulses was studied experimentally and theoretically. With the contactfree laser-based photoacoustic pump-probe technique, nondestructive testing could be extended to the characterization of elastic-shock-generated partially closed microcracks in the range of tens of micrometers.

By numerical simulations the propagation of thermoelastically launched broadband SAW pulses in nonlinear media and the initiation of crack growth is described. The characteristic features of SAW profiles in linear media, nonlinear media with quadratic nonlinearity, and nonlinear media with crack nucleation provide a versatile tool to extract crack properties and the critical stress of dynamic failure. Good agreement with experiments was obtained for isotropic fused quartz. By taking into account the modification of the SAW pulse shape by crack interaction and by applying the condition of vanishing shear stress at the crack tip, the angle of crack penetration into silica could be estimated.

Depth and size of these surface-breaking cracks in silica were studied theoretically and experimentally with linear SAW pulses. Schwarz-Christoffel conformal mapping was used to introduce a special orthogonal coordinate system that conserves the profile of the cracked surface. The inverse problem was solved for two dimensions by means of conformal mapping, to study scattering of SAWs by a single crack. The SAW component transmitted through the isolated microcrack was recorded as a function of distance by the cw laser probe-beam-deflection method. This allowed the evaluation of the crack depth. Sizing of cracks in the range of 20-100 om by linear SAWs was performed with a bandwidth 200 MHz. The radius of a semicircular surface-breaking crack in silica was evaluated using two methods, based on the experimentally measured reflection coefficient and on the frequency dependence of the phase lag of the transmitted wave. These quantities were also simulated numerically by means of the finite differences method (FDM), and fitted to the experimental ones by varying the assumed crack size. In both cases the interaction between crack faces was taken into account, and the crack size obtained acoustically was compared with the one measured by optical microscopy.