# Acoustical breakdown of materials by focused surface acoustic waves generated by laser pulses

David Veysset[1,2], Alex A. Maznev[1,2], Martin Hautefeuille[2], Thomas Pezeril[3], Steve Kooi[2], Alexey M. Lomonosov, Gagan Saini, and Keith A. Nelson[1,2].

dveysset@mit.edu

[1]Department of Chemistry, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA
[2]Institute for Solider Nanotechnologies, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA
[3]Laboratoire de Physique de l'Etat Condensé, UMR CNRS 6087, Université du Maine, 72085 Le Mans, France

Focusing of high-amplitude surface acoustic waves leading to material damage is visualized in an all-optical experiment. The optical set-up includes an axicon that focuses an intense picosecond excitation pulse into a ring-shaped pattern at the surface of a gold coated glass substrate in an arrangement resembling that recently used to focus shock waves in a thin liquid layer [1]. Optical excitation induces a surface acoustic wave (SAW) that propagates in the plane of the sample and converges toward the center. The evolution of SAW profile is monitored using interferometry with a femtosecond probe pulse at variable delays. A series of images is obtained tracing the converging wave as it collapses at the focal point. The quantitative analysis of the full-field images provides direct information about the surface displacement profiles, which are compared to calculations. The high strain amplitude at the focal point leads to the removal of the gold coating and, at higher energies, to damage of the glass substrate. The results open the prospect for testing material strength on the microscale using laser-generated SAWs.

References:

[1] T. Pezeril, G. Saini, D. Veysset, S. Kooi, PP. Fidkowski, R. Radovitzky, and Keith A. Nelson, Phys. Rev. Lett., 106, 214503 (2011).

Figures:

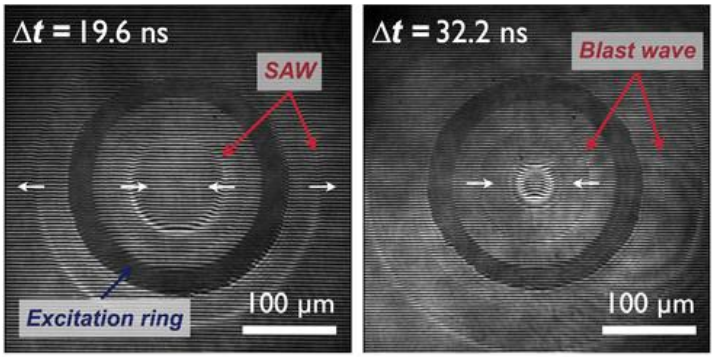


Figure 1: Interferometric images of propagating surface acoustic waves for an excitation energy of 0.2 mJ. The SAWs are generated

upon laser absorption (t=0 ns). The gold is ablated at the ring laser focus (dark ring on the images). The bend in the fringes gives us direct and quantitative information on the surface displacement . After 19.6 ns, the SAWs propagated of about a distance of 50 µm before reaching the center of focus after 32.2 ns. A blast wave is also generated at t=0 ns but travels slower than the acoustic wave.

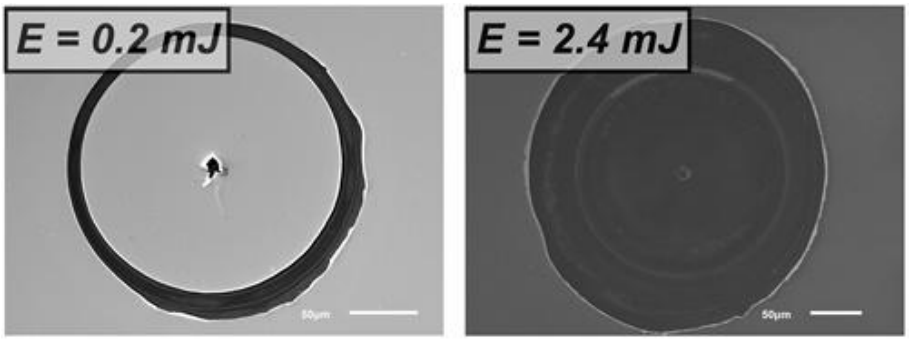


Figure 2: SEM micrographs of irradiated areas. (Left) At low energies, the gold coating is removed not only at the excitation ring but also at the center of it where the SAWs focused. (Right) At higher energies, the large amplitude of the SAWs caused damage in the glass substrate attesting of the large strain induced by the SAW focusing.