Pump–probe imaging of GHz surface waves for Young's modulus measurement

Ramon Auer[1], Ruben Burger[1,2], Goran E. Hallum[1], Dennis Schweiger[1], David Redka[1], Matthias Domke[3], Datong Wu[1], Heinz P. Huber[1]

1. Munich University of Applied Sciences HM, Lothstr. 34, Munich, 80335, Bavaria, German
2. Technical University of Munich - Chair of Nondestructive Testing, Franz-Langinger-Str. 10, Munich, 81245, Bavaria, Germany
3. Vorarlberg University of Applied Sciences - Josef Ressel Center for Material Processing with Ultrashort Pulsed Lasers, Feldgut 9, Rankweil, 6830, Vorarlberg, Austria

*Corresponding author email: ramon.auer@hm.edu

Understanding GHz surface acoustic waves (SAWs) is critical for advancing nondestructive testing and material characterization in applications like semiconductor wafers and optical crystals. Traditional SAW measurement methods often rely on time-consuming point-based techniques, requiring multiple scans to capture angularly resolved wave propagation. This study employs a fast, full-field imaging approach using ultrafast pump–probe microscopy with subpicosecond infrared laser pulses in the ablation regime. This method captures angular propagation velocities of Rayleigh SAWs and high-velocity pseudo-SAWs in fused silica and x-cut quartz. Reflectivity modulations were recorded using a high-resolution sCMOS camera, enabling an observation of wavefront dynamics over a time delay range of 6–11.5 ns. The results matched finite element simulations, achieving relative errors between 2–5%. From the measured wave velocities, key material parameters such as Young's modulus and Poisson's ratio were derived in excellent agreement with literature values. This technique demonstrates potential for faster, accurate material characterization.