Time Resolved Scanning Acoustic Microscopy for Material Characterisation

Martin Weber[1], Felix Sundblad[1], Jere Hyvönen[1], Sami Hietala[2], Edward Haeggström[1], Ari Salmi[1]

[1]Electronics Research Laboratory, University of Helsinki, Finland, [1]Department of Chemistry, University of Helsinki, Finland

Scanning acoustic microscopy is a technique for non-destructive testing. It can generate images with high spatial resolution. The signal contains depth information, which allows us to obtain the 3D surface topography of the object. Due to the scanning approach, this kind of microscope is best suited to investigate static objects e.g. integrated circuits and fixed biological samples. In recent years, we have worked on increasing the scan speed (24 mm²/h at 2 µm resolution, 6 Mpixel/h) of our acoustic microscope and on boosting the SNR (56.2 dB) by using coded signals. With these improvements, we now generate a single image within minutes. This enables us to record time-elapsed data and opens the path to 4D microscopy. Here, we demonstrate 4D imaging with our microscope on model systems, e.g. addition cure silicon rubber. It cures at room temperature within a few hours. Introducing heat significantly increases the curing speed. We embedded resistive heating elements into the rubber and observed the mechanical changes during heating. This investigation is relevant, as this material can be 3D printed by locally introducing heat, e.g. with a focused ultrasonic beam. By better understanding how the amount of introduced heat and the temperature rise is related to the curing process, it will potentially be possible to further develop direct acoustic 3D printing. We also investigate a thermo-responsive hydrogel based on poly(N-isopropyl acrylamide) crosslinked with 3 mol-% bis-acrylamide. This material changes its mechanical properties when heated. The 4D ultrasonic microscopy sees these changes with high spatial resolution without touching the sample.