Focusing of low-cost ultrasonic transducers with 3D printed lenses for acoustic microscopy

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In acoustic microscopy single-element ultrasonic transducers are widely used. To perform a scan, they are moved over a test specimen mechanically. Often, the transducers are focused by a spherical mechanical lens to achieve a high lateral spatial resolution in the focal area. In our contribution we will present a simple and inexpensive approach to focus piezoelectric transducers in the low MHz range with 3D printed lenses. 3D printing based on the principle of stereolithography enables easy and rapid design and production of an acoustic delay path with an arbitrary lens geometry on the front side. For example, spherical lenses commonly used in acoustic microscopy can be printed with a user-defined focal length. The piezoelectric transducer is either glued to or clamped on the back of the printed delay path. Clamping additionally requires a coupling gel between lens and transducer for acoustic impedance matching. We will discuss how the material properties of the delay path must be taken into account in the lens design. Furthermore, results of the sound field mapping of the focused transducers obtained from pulse-echo measurements on a wire reflector will be shown. One major disadvantage of using ultrasonic transducers with a fixed focal length is the decreasing spatial resolution with increasing distance from the focus. However, in lateral scans this can be overcome using Synthetic Aperture Focusing Techniques like the Delay-and-Sum algorithm. We will present the results of post processing the measured sound field data of transducers focused with a 3D printed lens. These show that an approximately constant lateral spatial resolution is achievable over a wide depth range.