## Multimaterial Acoustic Holograms

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### Background, Motivation and Objective

*Conventionally, ultrasound fields are generated with single transducers in combination with lenses, resonators, horns or using phased array transducers to obtain more complex fields. We recently presented a facile method to form intricate ultrasound fields using a single transducer and 3D-printed phase plates computed via digital holography.[1] Restricting the holograms to phase-only modulation necessitates the use of optimization algorithms to retrieve a suitable phase map (i.e. the phase hologram). Certain target fields however require a fixed phase distribution in the target region and thus limit the solution space. Those problems benefit from full control over both amplitude and phase of a sound beam.*

### Statement of Contribution/Methods

*In this talk we present our efforts towards acoustic holograms encoding both amplitude and phase. This is made possible by selectively depositing low and highly attenuating materials into the hologram matrix using the multi-material fabrication capabilities of 3D-printers. Although the phase optimization step can be omitted, computation of the thickness map is more involved compared to previous work. The acoustic properties of available materials generally lead to unfeasibly thick holograms. However, least squares fitting can be used to obtain thickness maps that match the experimental constraints.*

### Results/Discussion

*The holograms are fabricated by a 3D-printer (Objet Connex 260) using two different commercial materials and by varying the total and relative thickness of the respective layers. Experimental hydrophone measurements will be shown and compared to simulation results. Preliminary results for a combined phase and amplitude multi-material hologram that is used to generate a bottle beam are shown in FIG. 1 and demonstrate the feasibility of this approach.*

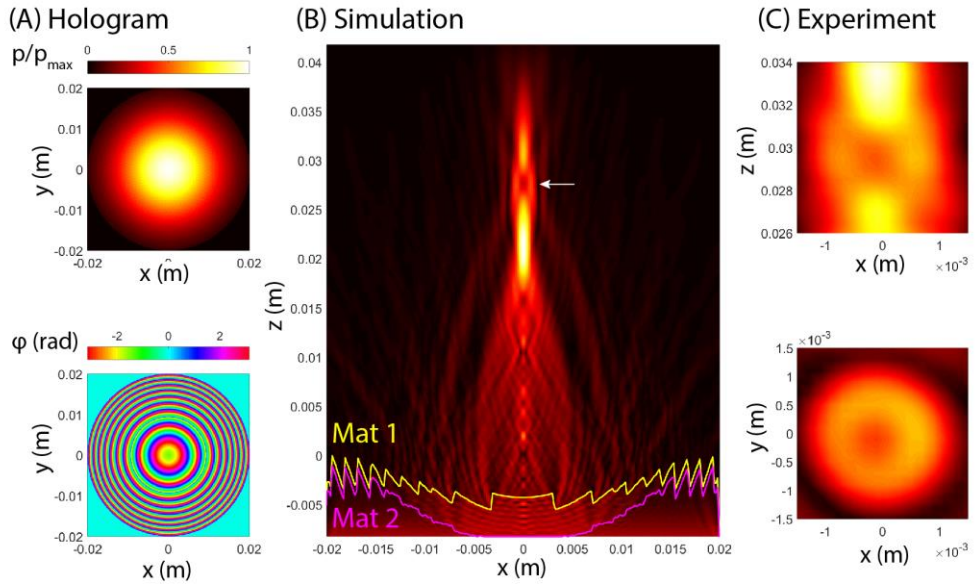


FIG 1: (A) Hologram amplitude (top) and phase map (bottom) for a bottle beam. (B) Simulation results (k-Wave), where the top surfaces of the two material layers are marked by colored lines. Material 2 is the more attenuating material. The arrow marks the bottle focus. (C) Hydrophone measurements through the focus.

### References

[1] *K. Melde, A. G. Mark, T. Qiu, and P. Fischer, "Holograms for acoustics," Nature, 537 (7621), 518-22 (2016).*