3D PRINTED MEMBRANE-TYPE ACOUSTIC METAMATERIALS FOR SMALL-SCALE APPLICATIONS

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OUTLINE

- Background and Motivations
- Acoustic metamaterials based on Helmholtz resonators
- 3D printing membranes
- Membranes-type metamaterials
- Conclusions and Future Work
BACKGROUND AND MOTIVATIONS

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- Lightweight, small scale
- There is a large range of materials to choose from with different properties
- It is possible to change the resonance frequency by modifying the design (DMM, etc.)
BACKGROUND AND MOTIVATIONS

- The need for developing 3D printing techniques for membrane-type acoustic metamaterials has been highlighted in papers
- 3D printing gives a high degree of similarity among the samples, which is difficult to obtain in manually glued membranes

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ACOUSTIC METAMATERIALS BASED ON HELMHOLTZ RESONATORS


3D PRINTING MEMBRANES

CAD Model

Upside-Down Stereolithography

https://www.asiga.com
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Materials Properties

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<th></th>
<th>PMMA</th>
<th>PEGDA</th>
<th>BEMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young's Modulus (Pa)</td>
<td>$1.8 \times 10^9$</td>
<td>$50 \times 10^6$</td>
<td>$3 \times 10^6$</td>
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<tr>
<td>Density (Kg/m$^3$)</td>
<td>1180</td>
<td>1180</td>
<td>1099</td>
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<tr>
<td>Poisson’s Ratio</td>
<td>0.33</td>
<td>0.35</td>
<td>0.4</td>
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- Trial and error process
- Increasing exposure time increases the thickness
- Increasing the quantity of absorber decreases the thickness
- Different materials need different exposure times and amount of absorber to obtain the same thickness
• Membranes increase and broaden the bandgap
• The resonance frequency is higher than expected due to stress added by the 3D printer
CONCLUSIONS

• We successfully 3D printed thin membranes.
• By printing the membranes on the bottom of Helmholtz resonators it was possible to achieve broader and deeper band gaps.
• However, the resonance frequency of the membranes was higher than the one predicted analytically.

FUTURE WORK

• To test the sound transmission loss through impedance tube or other measurement techniques.
• To design and print acoustic metamaterials based on different kind of membranes and materials.
• To finally build and test audio devices and conduct psychoacoustic evaluations.
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