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Laser-enabled experimental evidence of bandgaps in 3D-printed phononic crystals

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Project Background

- This project aims at providing experimental evidence of the bandgap phenomenon in 3D-printed elastomeric phononic crystals using laser vibrometry sensing

Objectives

- Illustrate the potentials of laser vibrometry as a tool to characterize smart material and structures at large.
- Show 3D printing as a viable option to manufacture smart materials with complex topologies and unconventional properties.

What are Phononic Crystals?

- Synthetically-made materials with a periodic spatial arrangement of unit cells
- Our Phononic Crystal

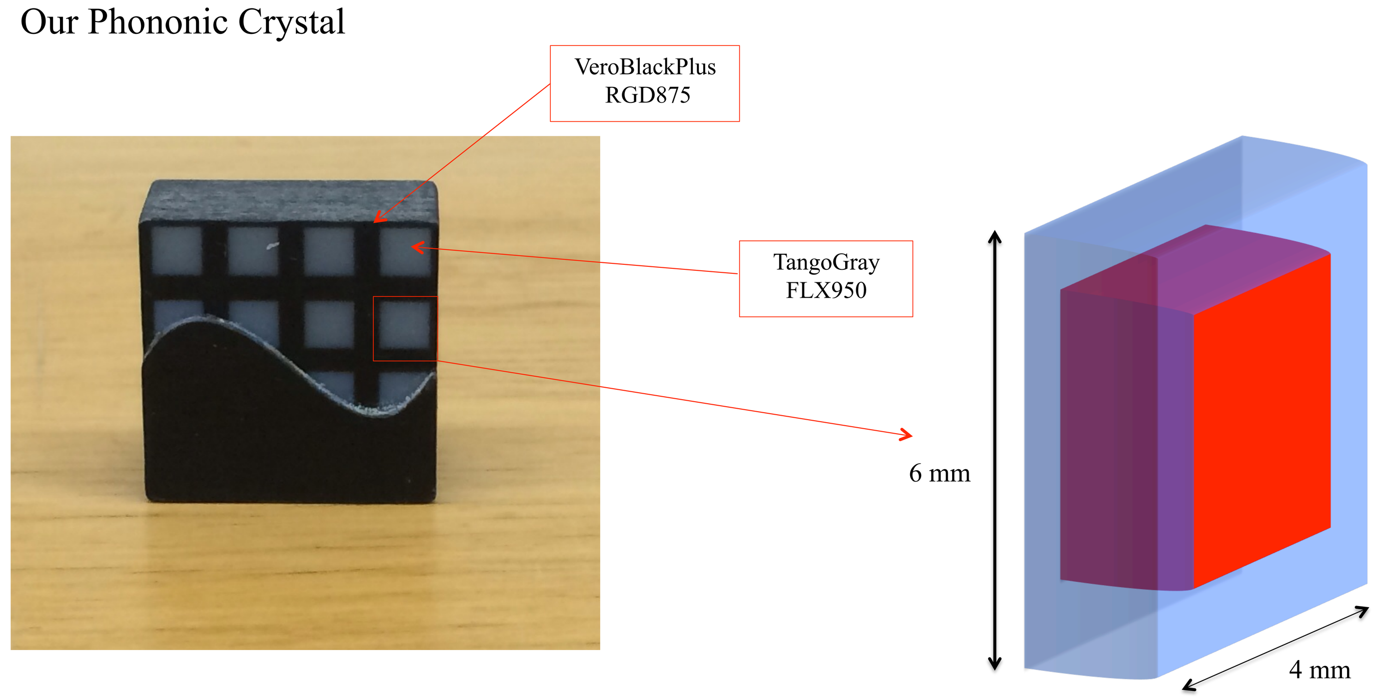

Fig. 1: Coupon of Tested Material from 3D printer and its corresponding unit cell

What is a Bandgap?

- Frequency band in which waves cannot propagate through the material

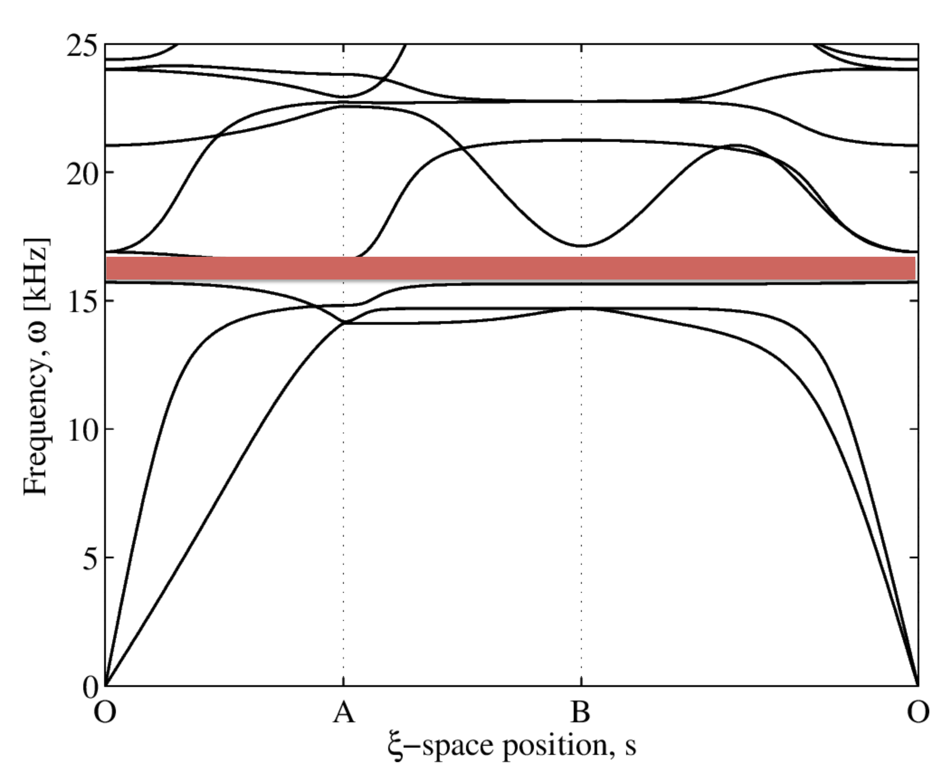

Fig. 2: Bandgap behavior of specimen, shown in RED, simulated in MATLAB for a moduli ratio between materials of 100:1

Specimen Preparation

Fig. 3: Stratasys 3D printer utilized to manufacture the specimen

Note: the properties of the material obtained by 3D printing (e.g. Young's modulus and density) were unknown

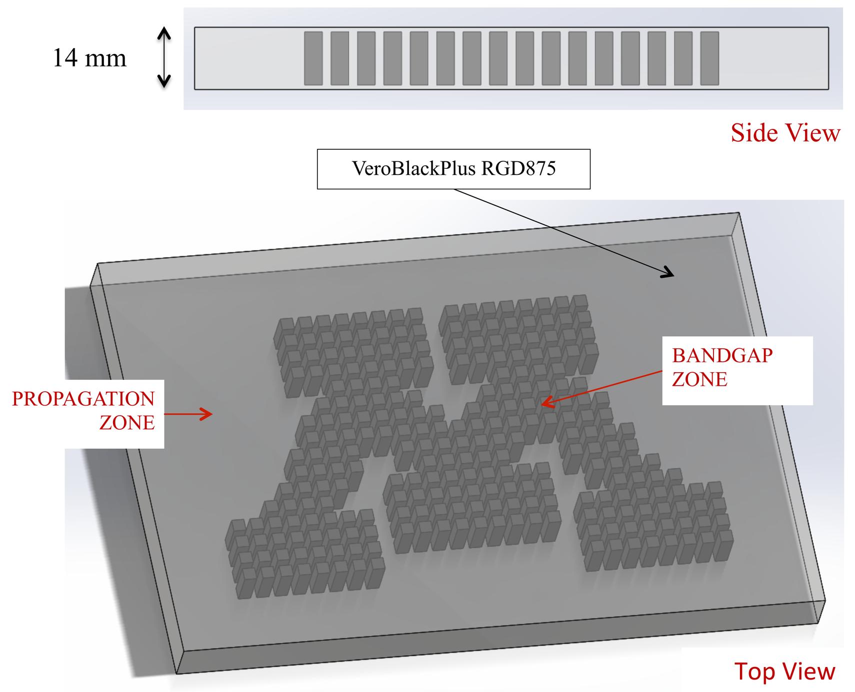

Fig. 4: Specimen drawing for 3D printer showing dark sheet concealing the "M" core

Testing Equipment

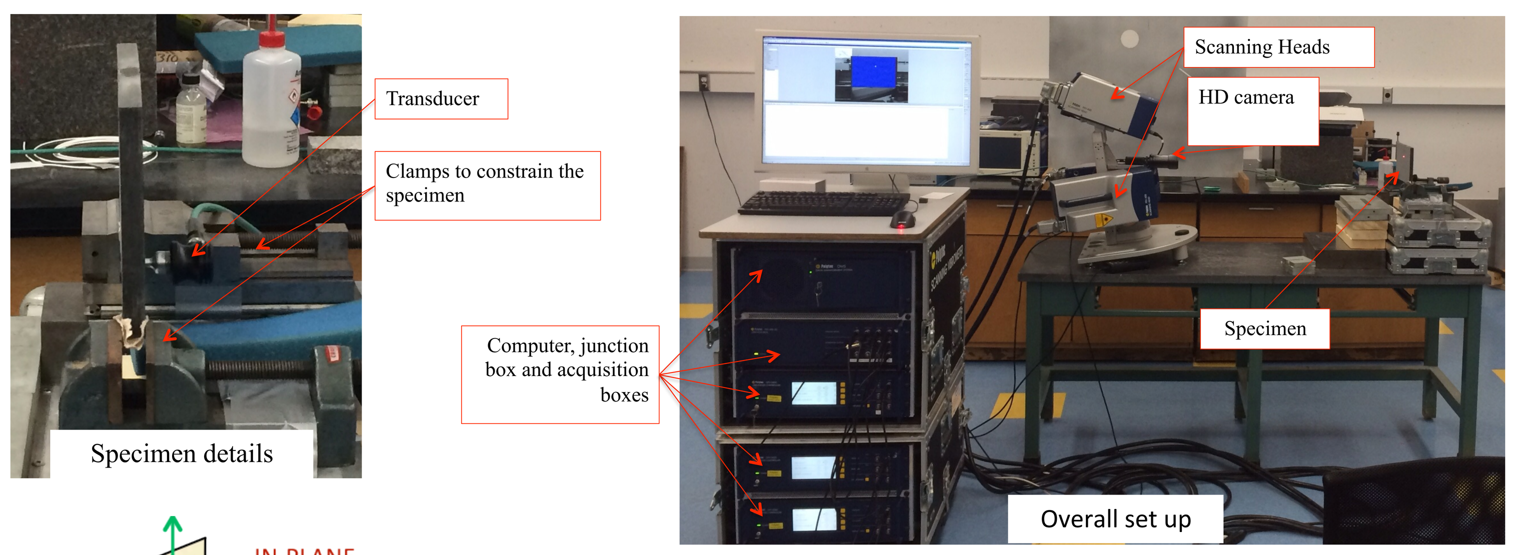

Fig. 5: Specimen and testing set-up

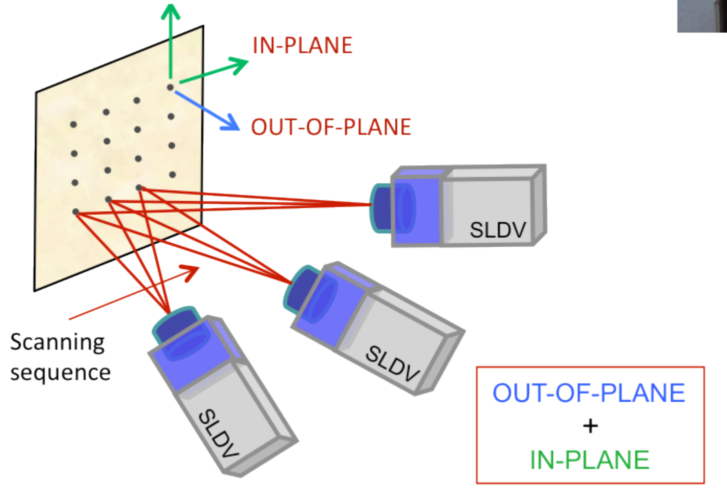

Fig. 6: Principles of 3D scanning laser vibrometry

Features of 3D vibrometer

- Non-contact (Non-intrusive)
- Reconfigurable
- Remote sensing

Frequency Range Identification

- Pseudorandom excitation
- Bandgap condition identified by inspection of the deformation shapes at several points in the spectrum
- Major energy peaks in the specimen occurred at 144 [kHz] & 172 [kHz].

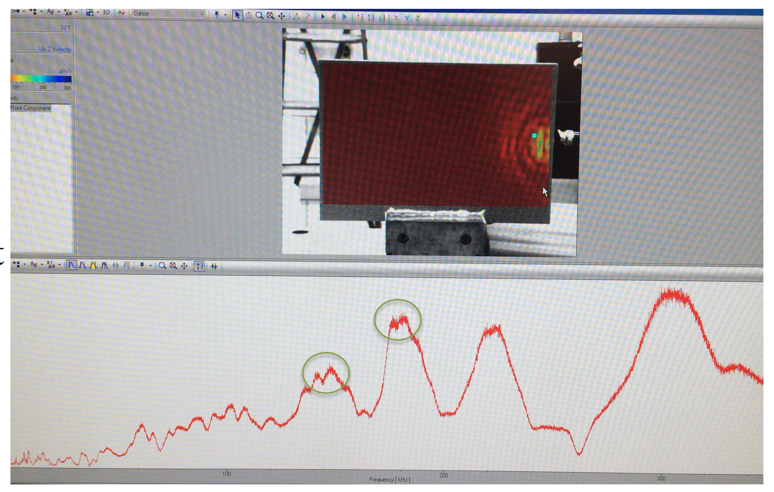

Fig. 7: Data collected using a pseudorandom excitation near the interface of the "M"

Results from 3D Laser Vibrometer Acquisition

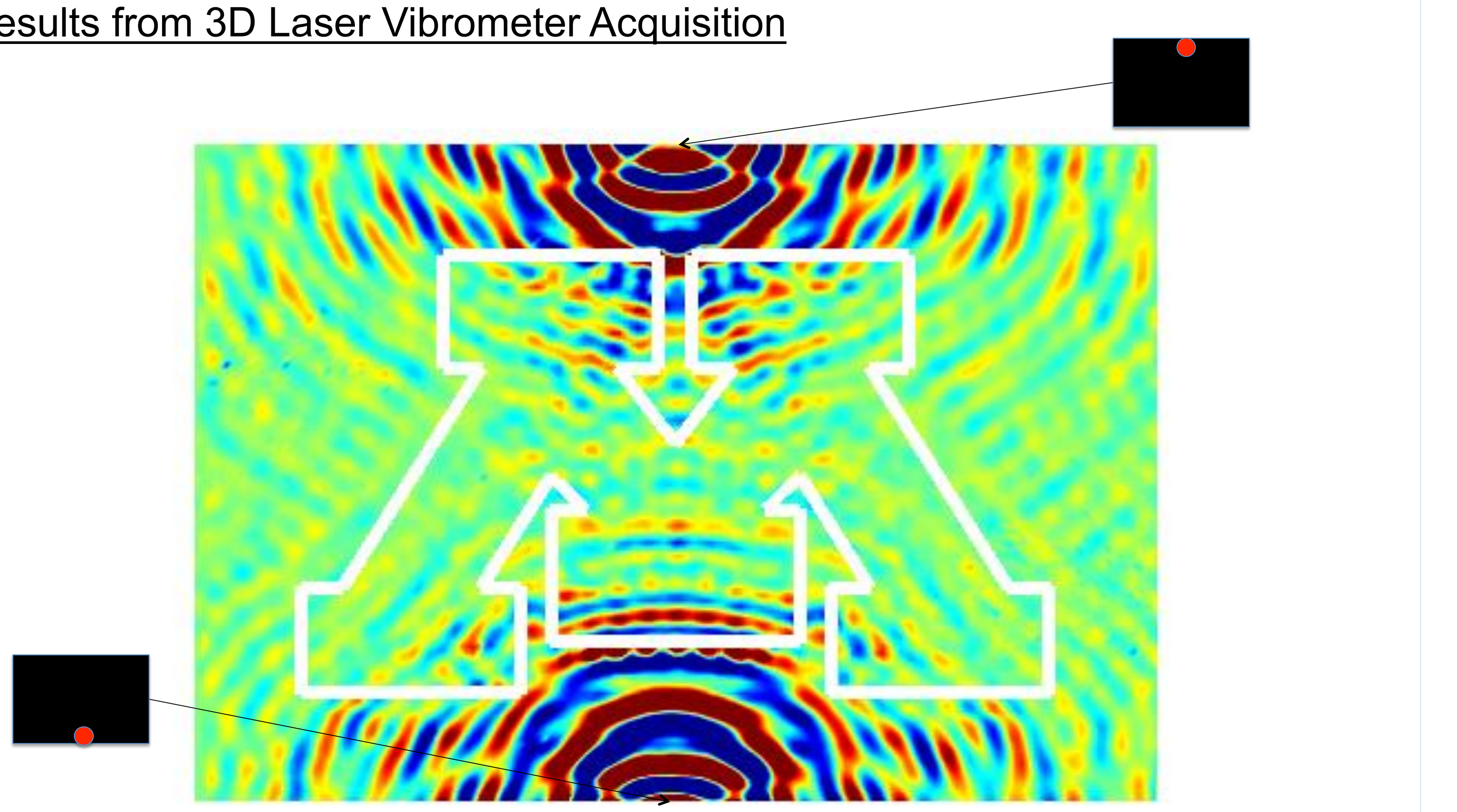

Fig. 8: Superimposed data from two separate tests with force applied at the top and bottom of the specimen

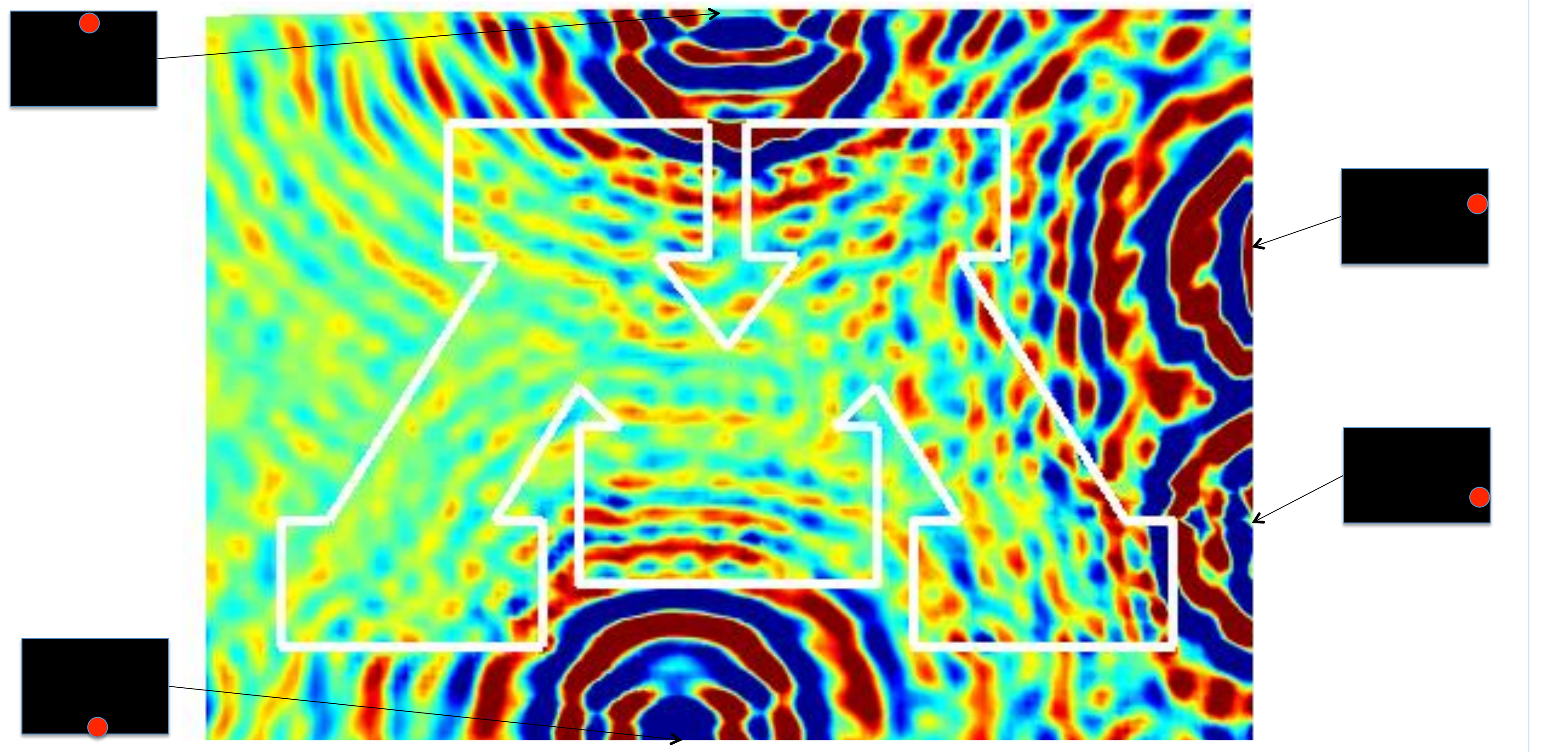

Fig. 9: Superimposed data from four separate scans (same boundary conditions) with force applied at the top, bottom, top right and bottom right of the specimen

Conclusion

In addition to offering compelling visual evidence of bandgap conditions in a solid phononic crystal, this experiment illustrates the potentials of laser vibrometry as a tool to characterize smart materials and structures at large. It also suggests that 3D printing is a viable option to manufacture smart material prototypes with complex topologies and unconventional properties.

Acknowledgement

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References

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