BIMETALLIC LENSES FOR FOCUSING ULTRASOUND

IITM Technology Available for Licensing

Problem Statement

- Traditional ultrasonic testing is **limited by the diffraction limit,** preventing detection of defects smaller than half the wavelength, which **affects the ability to identify subwavelength anomalies** in materials.
- Existing techniques like **evanescent wave imaging and metamaterials are complex, difficult to implement**, and fail to provide practical, high-resolution solutions for ultrasound testing.
- Moreover, methods based on **negative refraction or backward wave propagation cannot efficiently focus ultrasound waves**, limiting their ability to resolve subwavelength anomalies across various applications.
- There is a need for a **bimetallic lens system that efficiently focuses ultrasound waves** while **improving the resolution and enabling the detection of subwavelength anomalies** in structural health monitoring and medical diagnostics.

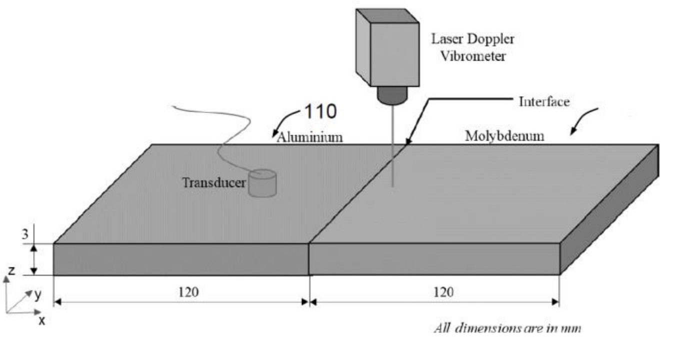

Figure: Bimetallic Lens System for Focusing Ultrasound Waves

Intellectual Property

- IITM IDF Ref 1818
- **IN 548806 Patent Granted**

TRL (Technology Readiness Level)

TRL 3 Experimental Proof of Concept

Technology Category/ Market

Category- Non-Destructive Testing Methods & Equipment (NDT/NDE)

Industry Classification:

NIC(2008)- 26511 Manufacture of physical properties testing and inspection equipment

NAICS(2022)-334519 Other Measuring and Controlling Device Manufacturing (Physical properties testing and inspection equipment)**; 7120** Technical testing and analysis

Applications:

Detection of sub-wavelength defects in structural health monitoring in aerospace, civil engineering, and manufacturing; super-resolution imaging; diagnostic imaging for conditions that require precise identification; wearable ultrasound sensors or point-of-care diagnostic devices; defect detection in complex materials.

Market report:

Global Structural Health Monitoring Market was valued at USD 2.43 billion in 2023 and is projected to grow to USD 5.32 billion by 2031 with a CAGR of 10.30%.

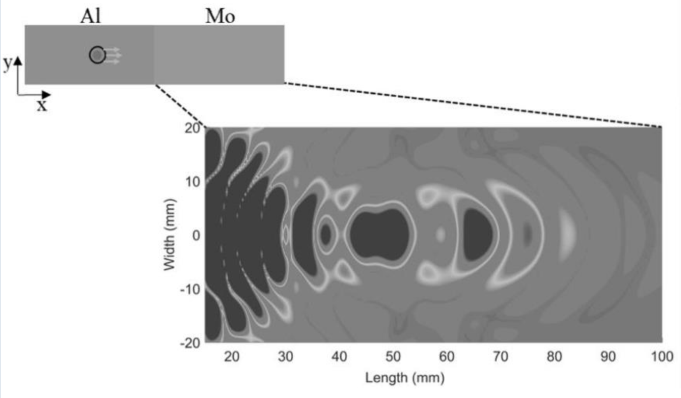

Figure: A graphical representation of simulation results focusing observed in the second material section of the Al-Mo bimetallic lens

Research Lab

Prof. Prabhu Rajagopal
Dept. of Mechanical Engineering

CONTACT US

Dr. Dara Ajay, Head TTO
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: headtto-icsr@icsrpis.iitm.ac.in
tto-mktg@icsrpis.iitm.ac.in
Phone: +91-44-2257 9756/ 8369

IIT MADRAS
Indian Institute of Technology Madras

Technology Transfer Office
TTO – IPM Cell

Industrial Consultancy & Sponsored Research (IC&SR)

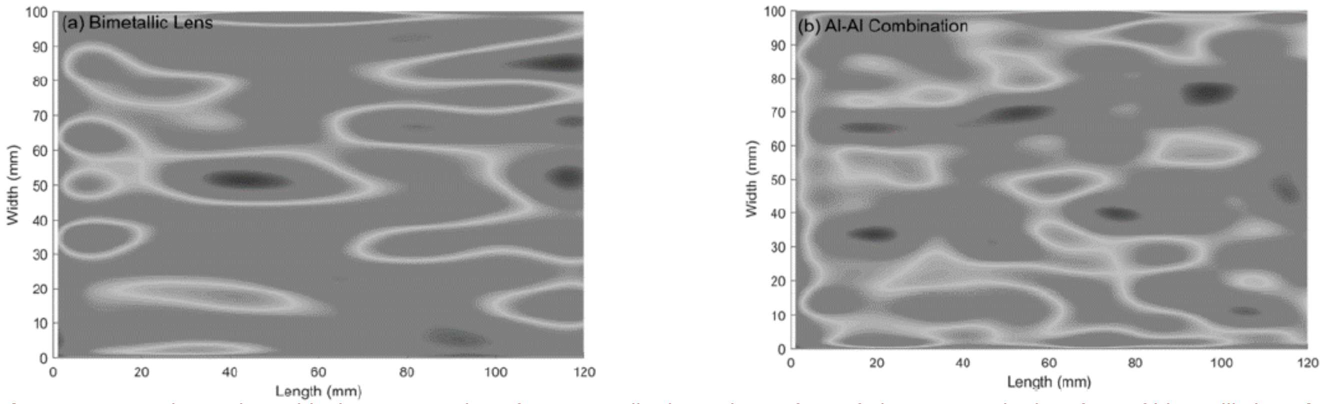

Figure: An experimental graphical representation of wave amplitude on the surface of plate across the interface of bimetallic lens **(a)** and Al-Al combination **(b)**. the waves are focused in bimetallic lens at a distance of 17 mm from the interface or at 117 mm from the excitation end, when compared to Al-Al combination

Technology

- The lens system uses a combination of two materials, typically Aluminium (Al) and Molybdenum (Mo), where ultrasonic waves generated in the first material (Aluminium) are focused into the second material (Molybdenum). The materials are selected such that the forward wave (S2) in the first material is converted to a backward wave (S2b) in the second material at the same frequency-wave number combination, facilitating super-resolution in ultrasound wave imaging.
- The bimetallic lens works on the principle of negative refraction caused by mode conversion of ultrasonic guided waves. This allows for focusing of waves beyond the diffraction limit, a key feature that enables super-resolution in imaging applications.
- The materials used for the bimetallic lens are carefully selected for their mechanical properties and compatibility in terms of wave propagation modes. Aluminium is chosen for its availability and cost-effectiveness, while Molybdenum (or other metals like Brass, Chromium, Copper, and Titanium) is selected for its ability to support backward wave (S2b) propagation and for optimizing the focusing effect
- **The bimetallic lens is designed to be versatile and applicable in a broad range of industries, including medical imaging (e.g., resolving subwavelength anomalies in tissues) and structural health monitoring (e.g., detecting cracks or defects in materials). The lens system can be miniaturized and arranged in stacks for more complex imaging tasks or beam steering applications.**
- **Experimental and simulation results show that the bimetallic lens provides a focused ultrasound spot with a reduced Full Width at Half Maximum (FWHM), indicating improved resolution compared to traditional systems**

Key Features / Value Proposition

- Unlike conventional ultrasound systems that are limited by diffraction limits, this bimetallic lens achieves super-resolution, enabling the detection and imaging of subwavelength defects, which existing systems may fail to resolve.
- The focusing using the invented bimetallic lense can clearly be observed at the center of the plate, and this is quite prominent as compared to the more diffuse distribution of wave energy in an Al-Al combination.
- Traditional lenses typically rely on positive refraction, leading to broader focal spots. The bimetallic lens, through negative refraction, achieves tighter focusing and higher energy concentration at the focal point, improving resolution significantly.
- The ability to select and combine different materials (e.g., Aluminum, Molybdenum, Brass, etc.) gives the bimetallic lens a level of customizability not present in single-material lenses.
- Unlike complex metamaterials or photonic crystal (PC) lenses, the bimetallic lens offers a simpler design that can be easily fabricated. This results in lower manufacturing costs and easier implementation in practical settings.

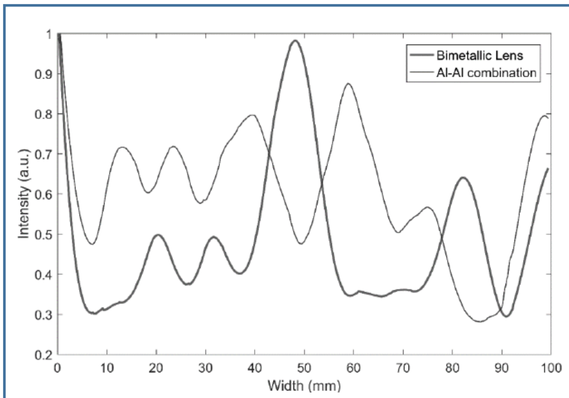

Figure: A graph showing the variation of the measured out-of-plane displacement amplitude along the width for bimetallic lens and Al-Al combination. The focusing can clearly be observed at the center of the plate, and this is quite prominent as compared to the more diffuse distribution of wave energy in an Al-Al combination

CONTACT US

Dr. Dara Ajay, Head TTO
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website: https://ipm.icsr.in/ipm/

Email: headtto-icsr@icsrpis.iitm.ac.in
tto-mktg@icsrpis.iitm.ac.in

Phone: +91-44-2257 9756/ 8369