HiFFUT – A New Class of Transducer

Project Meeting

19th March 2018

Dr Andrew Feeney

FLEXIM
when measuring matters

NATIONAL NUCLEAR LABORATORY

DYNOPTIC

DETECTRONIC
FLOW MEASUREMENT AND DATA DELIVERY

WARWICK

EPSRC
Engineering and Physical Sciences Research Council

EP/N025393/1

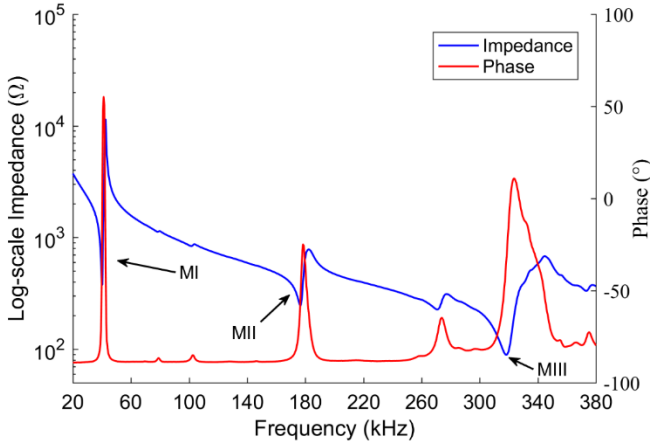
EES RESEARCH LTD

CYGNUS INSTRUMENTS

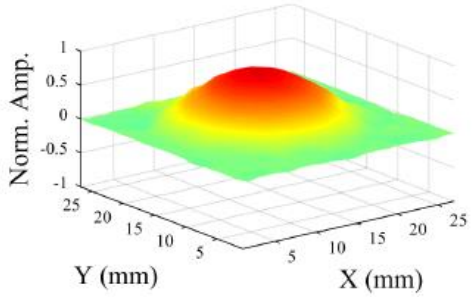
katronic

High Frequency Ultrasound Measurement

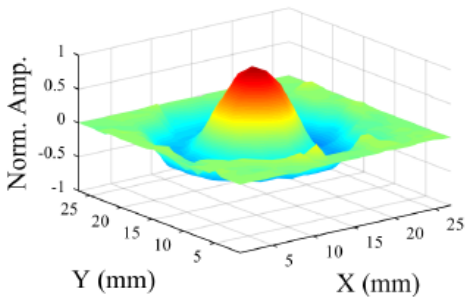
- Measurement of high frequency ultrasound in air using two FUTs, one as a transmitter and one as a receiver.
- Separation: 500 mm, but with the capacity for data acquisition at much greater distances.



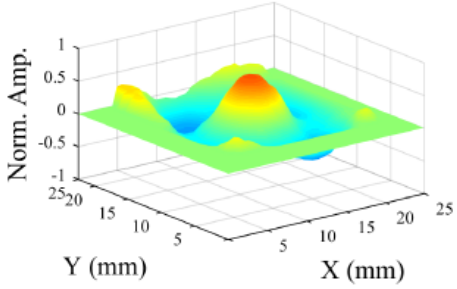
Impedance Analysis



(0,0) Mode at 40.5 kHz



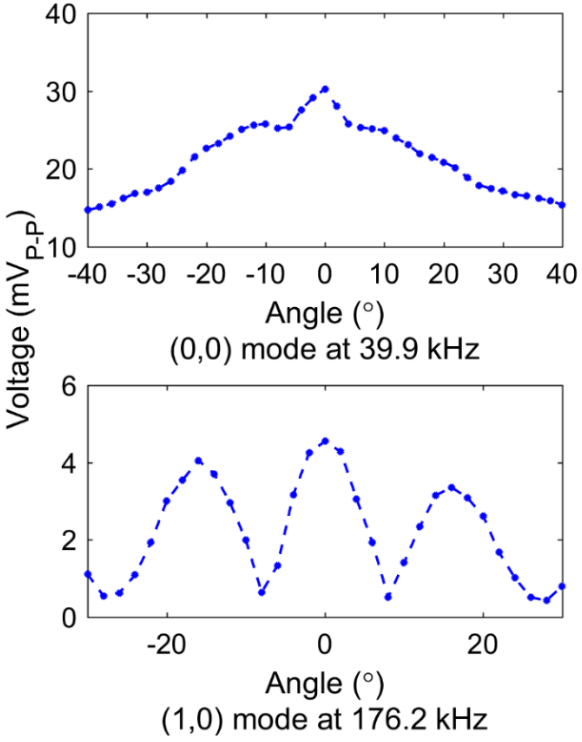
(1,0) Mode at 177.4 kHz

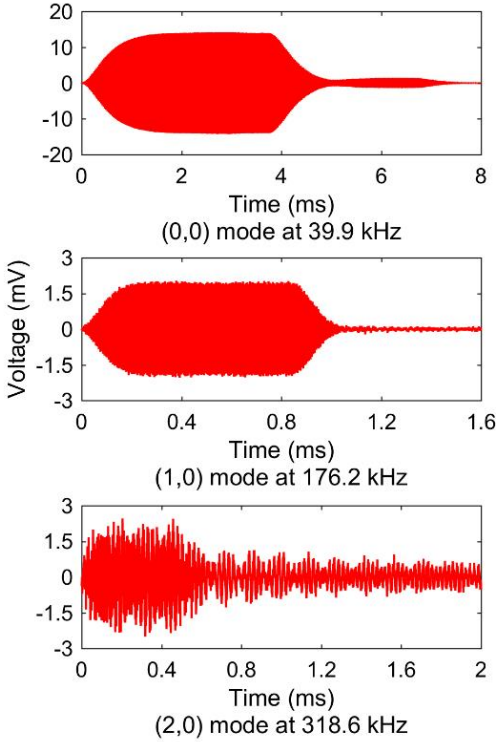


(2,0) Mode at 318.7 kHz

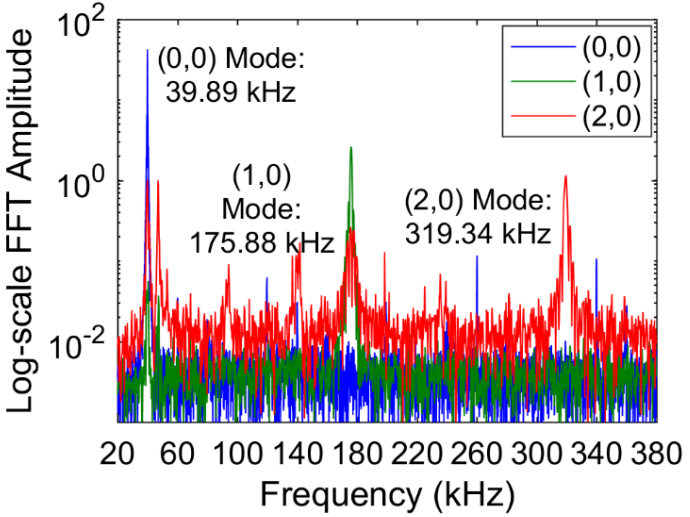
Mode Shapes from LDV

High Frequency Ultrasound Measurement



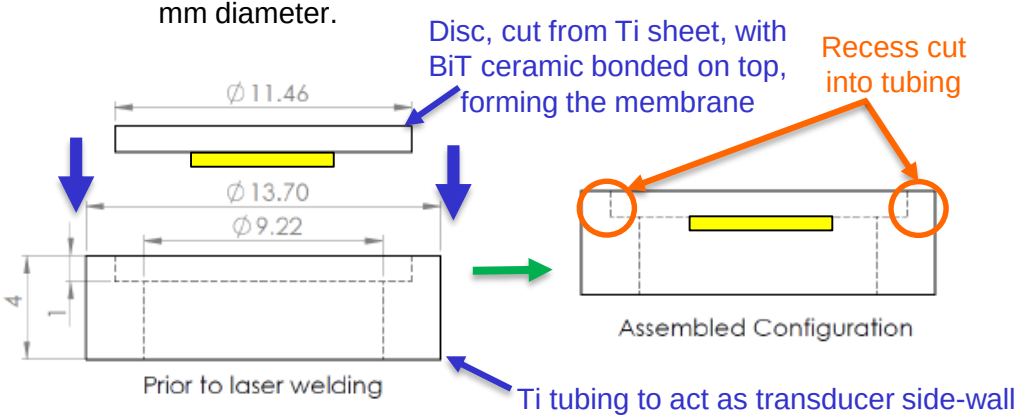


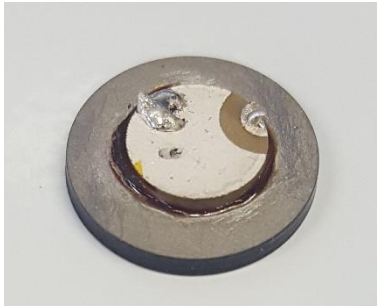
All data recorded with one FUT as a transmitter and one as a receiver separated by 500 mm

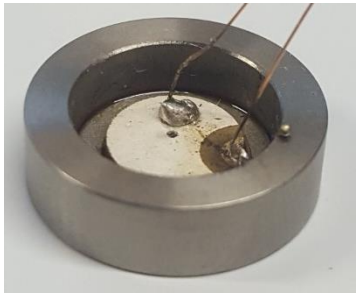


High Temperature HiFFUTs

- Two high temperature HiFFUTs constructed.
- Custom pressure rig used to bond components together.
- A high temperature epoxy resin (EPO-TEK® 353ND) used.
- Titanium (Grade 2 ASTM) cap.
- PZ46 bismuth titanate (BiT) ceramic (Meggitt), 0.89 mm thick, 6.35 mm diameter.



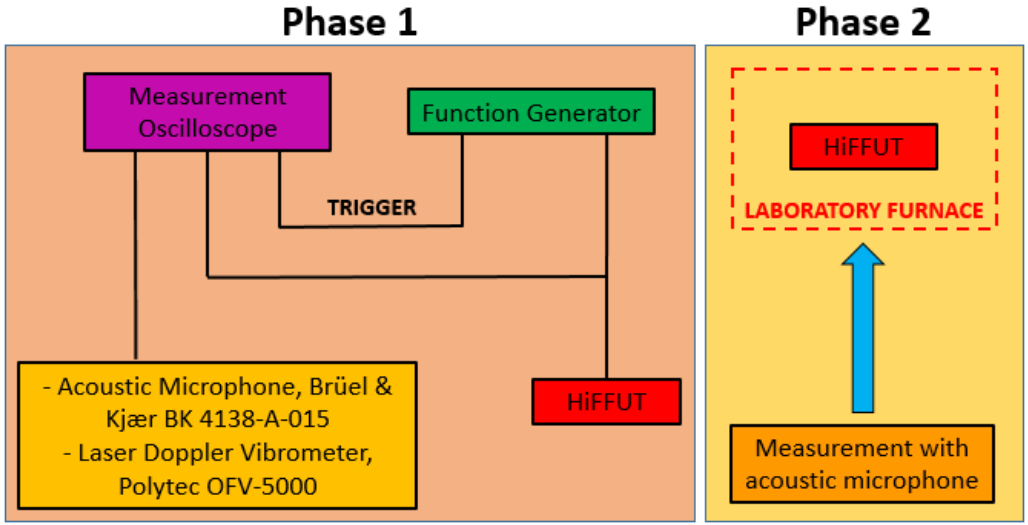




Cap components fabricated from laser welding

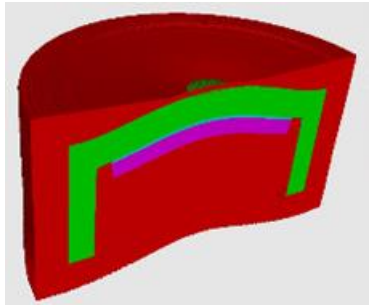
High Temperature HiFFUTs

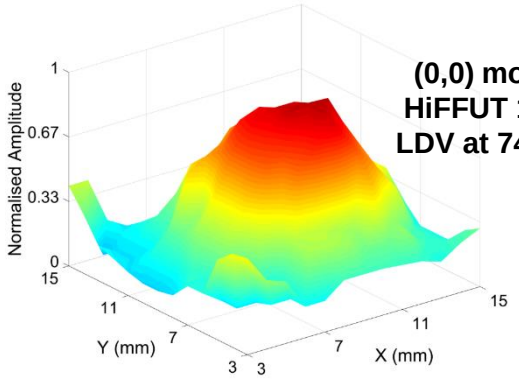
- LDV and microphone measurements (distance of 65 mm) undertaken at room temperature prior to thermal characterisation.
- Laboratory furnace (Pyrotherm) used for thermal characterisation, at 300 mm.



Experimental process

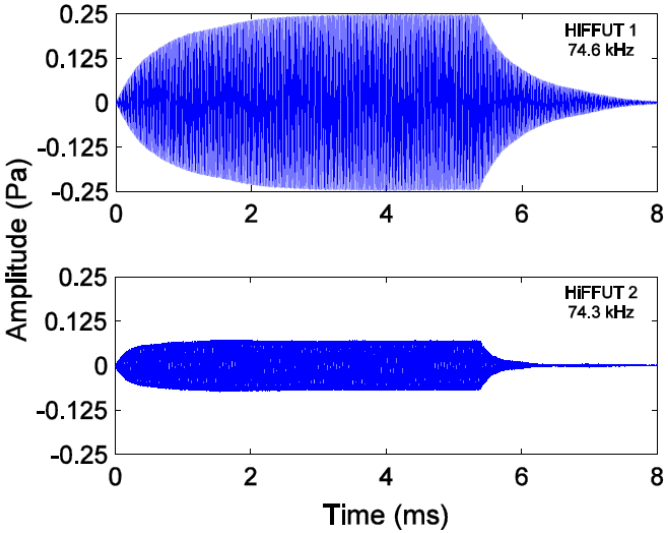
(0,0) mode, PZFlex FEA



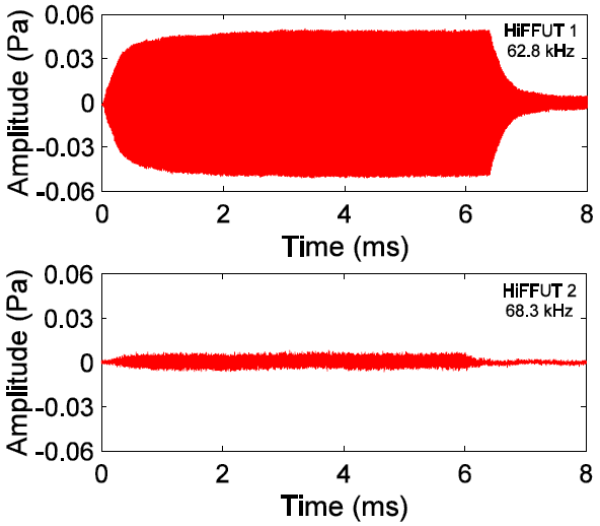


(0,0) mode of HiFFUT 1 from LDV at 74.5 kHz

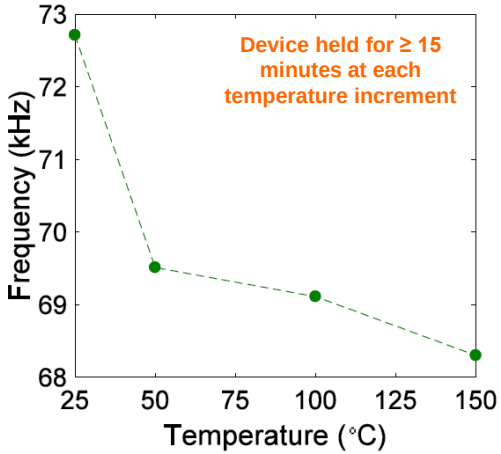
High Temperature HiFFUTs



Room temperature, 65 mm



150°C, 300 mm



HiFFUT 2 Response

Burst signal of 400 cycles at 20 V_{P-P}

Measurement at High Pressure

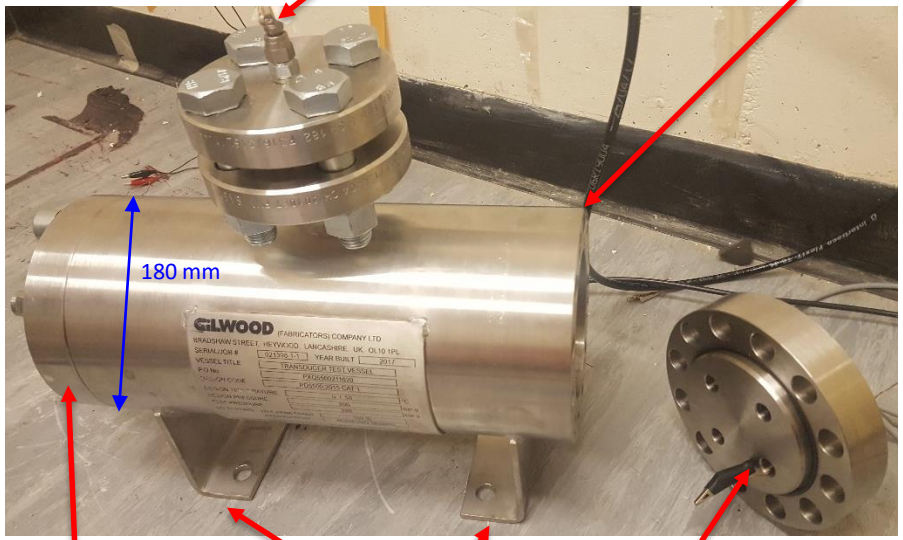
- Full system assembled and tested, with a ratiometric pressure sensor (Honeywell) for pressure measurement.
- Two M.Phys. dissertation students have conducted tests on commercial FUTs and FUTs with oil in the housing.

Thermal Detection Ltd High Pressure Insulated Wire Sealing Gland (HPPL)
- Viton sealant
- Seals up to 2070 bar (at 20°C)
- Grade 316L stainless steel

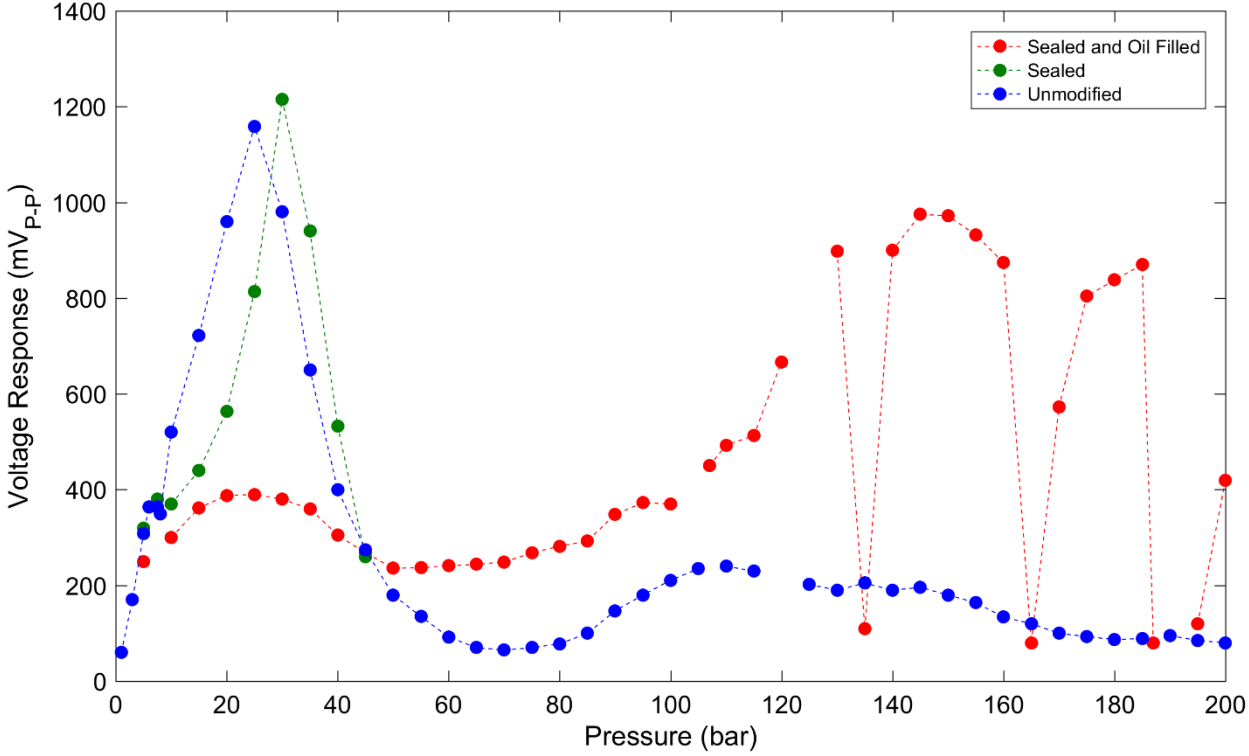
Honeywell Pressure Sensor
- 1/4”-18NPT Connection
- Rated up to 3000 psi (207 bar)
- Ratiometric

MK4 Hill Air Pump
- 1/8” BSP Connection
- Rated up to 4000 psi (276 bar)

Outside diameter [mm]	Wall thickness [mm]	Volume (l)	Weight [kg]
180	27	2.2	45



Sample Data at High Pressure



Research Output (Sep. 2017 – Present)

PAPERS

- A. Feeney, L. Kang, and S. Dixon, "High frequency measurement of ultrasound using flexural ultrasonic transducers," *IEEE Sensors Journal*, Accepted subject to approval of revision, 2018.
- A. Feeney, L. Kang, G. Rowlands, and S. Dixon, "HiFFUTs for high temperature ultrasound," *Proceedings of Meetings on Acoustics*, vol. 32, no. 1, 045003, 2017.
- A. Feeney, L. Kang, G. Rowlands, and S. Dixon, "Dynamic characteristics of flexural ultrasonic transducers," *Proceedings of Meetings on Acoustics*, vol. 32, no. 1, 045002, 2017.
- L. Kang, A. Feeney, and S. Dixon, "Flow measurement based on two-dimensional flexural ultrasonic phased arrays," *Proceedings of Meetings on Acoustics*, vol. 32, 2017.
- A. Feeney, L. Kang, and S. Dixon, "Nonlinearity in the dynamic response of flexural ultrasonic transducers," *IEEE Sensors Letters*, vol. 2, no. 1, pp. 1-4, 2018.
- A. Feeney, L. Kang, G. Rowlands, and S. Dixon, "The dynamic performance of flexural ultrasonic transducers," *Sensors*, vol. 18, no. 1, 270, pp. 1-14, 2018.

PRESENTATIONS & PUBLIC ENGAGEMENT

- **A. Feeney**, L. Kang, and S. Dixon, "HiFFUTs for high-temperature ultrasound," *The 2017 International Congress on Ultrasonics*, Honolulu, Hawaii, USA, December 2017.
- **A. Feeney**, L. Kang, G. Rowlands, and S. Dixon, "Dynamic characteristics of flexural ultrasonic transducers," *The 2017 International Congress on Ultrasonics*, Honolulu, Hawaii, USA, December 2017.
- L. Kang, **A. Feeney**, and S. Dixon, "Flow measurement based on two-dimensional flexural ultrasonic phased arrays," *The 2017 International Congress on Ultrasonics*, Honolulu, Hawaii, USA, December 2017.
- A. Feeney and L. Kang, demonstrators of ultrasonics and HiFFUT research to the public, *XMaS Science Gala*, University of Warwick, January 2018.

Next Steps

- Complete fabrication and testing of demonstrator piezoelectric HiFFUTs.
- Develop the second phase of HiFFUTs for high temperature applications, accounting for the outcomes from the first phase reported at the 2017 International Congress on ultrasonics.
- Construct and test a laser-welded HiFFUT.
- Design HiFFUTs for high pressure environments towards 200 bar.

Project Gantt Chart