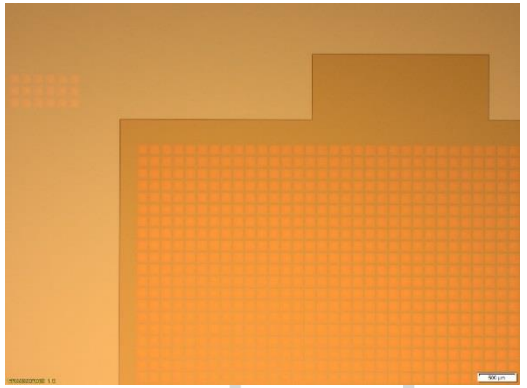


MEMS ULTRASONIC TRANSDUCERS : TECHNOLOGIES AND APPLICATIONS

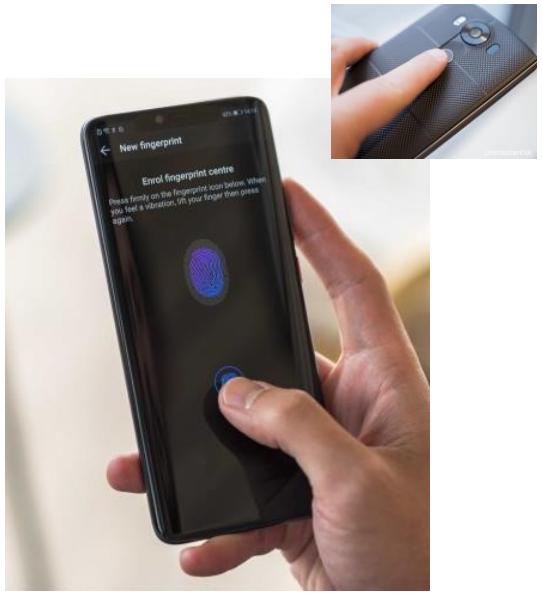
Bruno FAIN

Leti MEMS Workshop, June 25 2019, Estrel Congress Center, Berlin

ULTRASONIC TRANSDUCERS: APPLICATIONS:

In vivo imaging

Fingerprint sensor

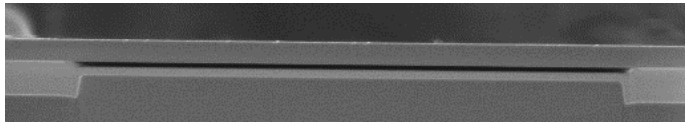


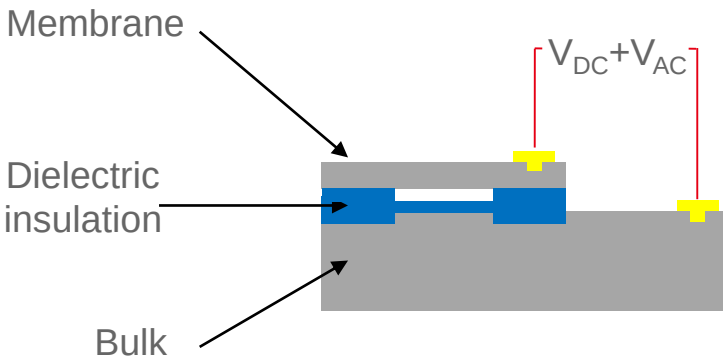
Ultrasonic tracking solutions for AR / VR

cMUT for handheld device

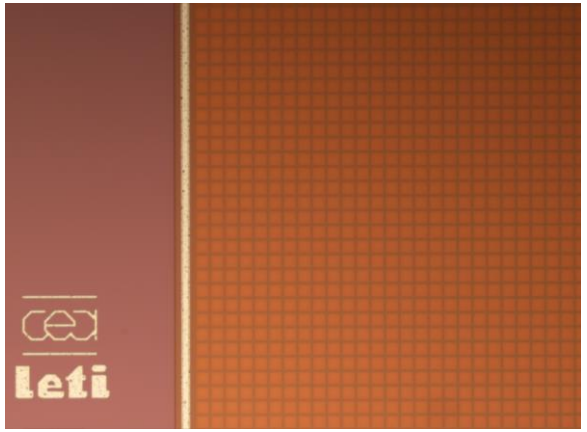
CAPACITIVE MICROMACHINED ULTRASOUND TRANSDUCER (CMUT)

CMUT single membrane

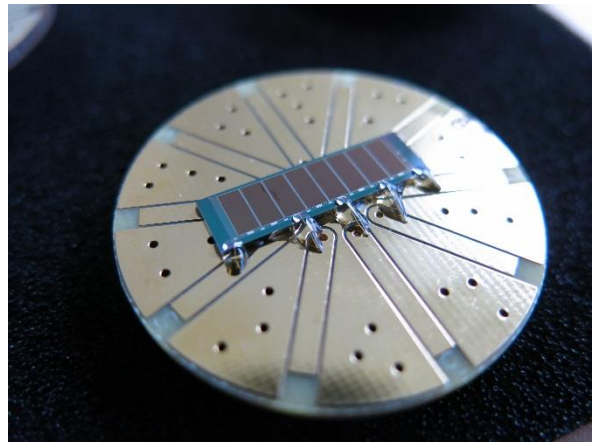




cMUT single element



cMUT die



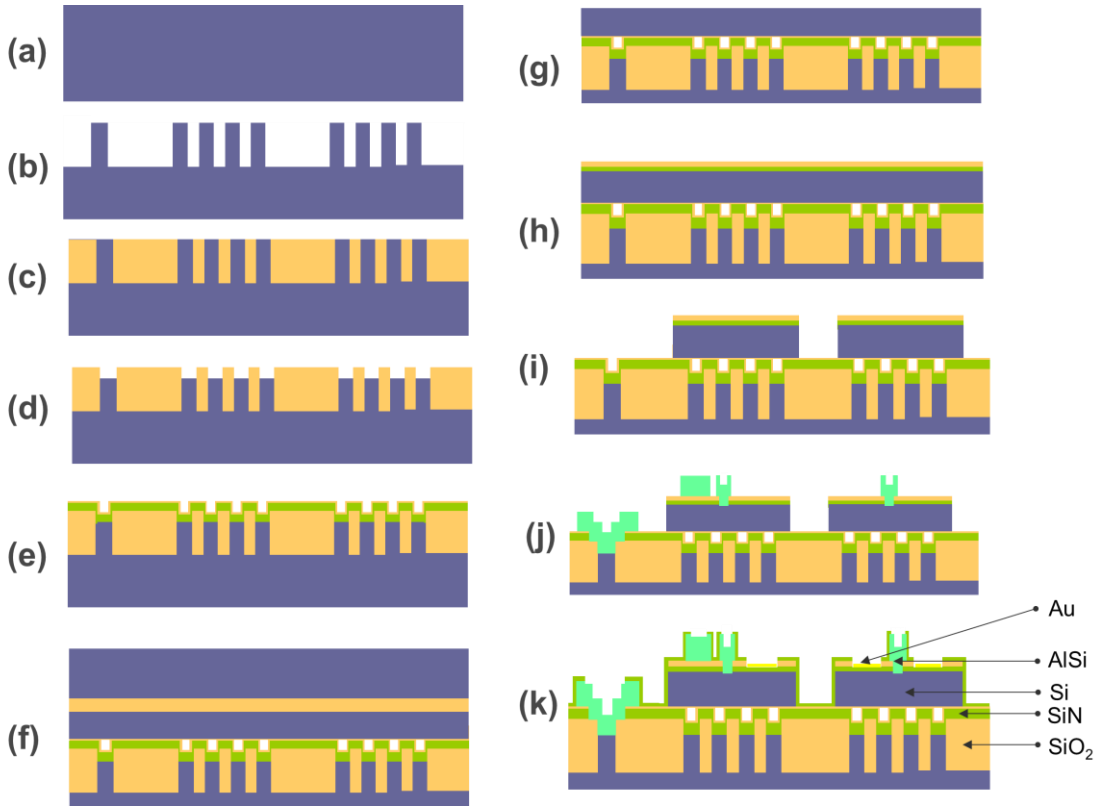
Pros :

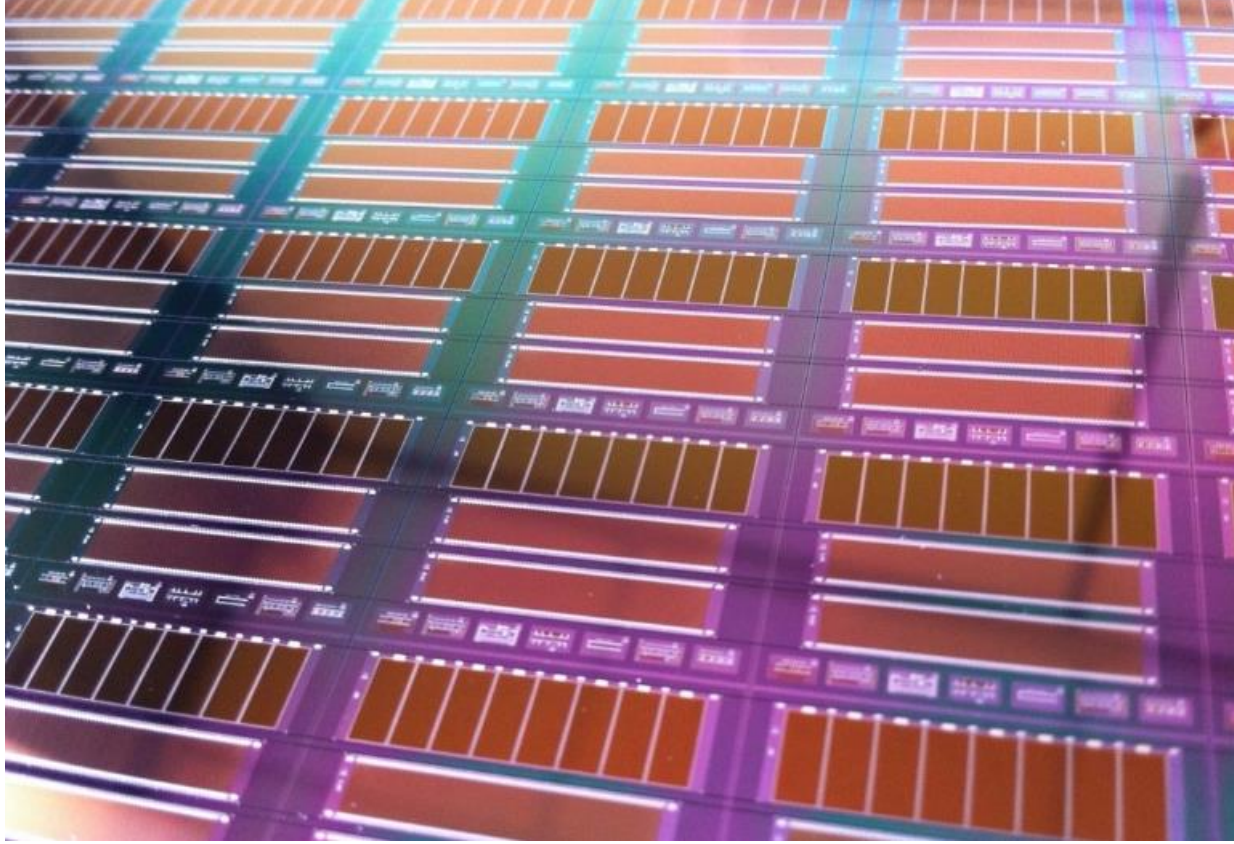
- **Good die-to-die and wafer-to-wafer homogeneity**
- **Mature process (Sacrificial release / Wafer bonding)**
- **Compactness / Ease of integration**
- **Large bandwidth**

Contras:

- **High DC bias required (~ 100V)**
- **Gap-limited displacement**
- **Complexity of low frequency devices (<200 kHz)**
- **Charging effects in dielectrics**

CMUT @ LETI - PROCESS



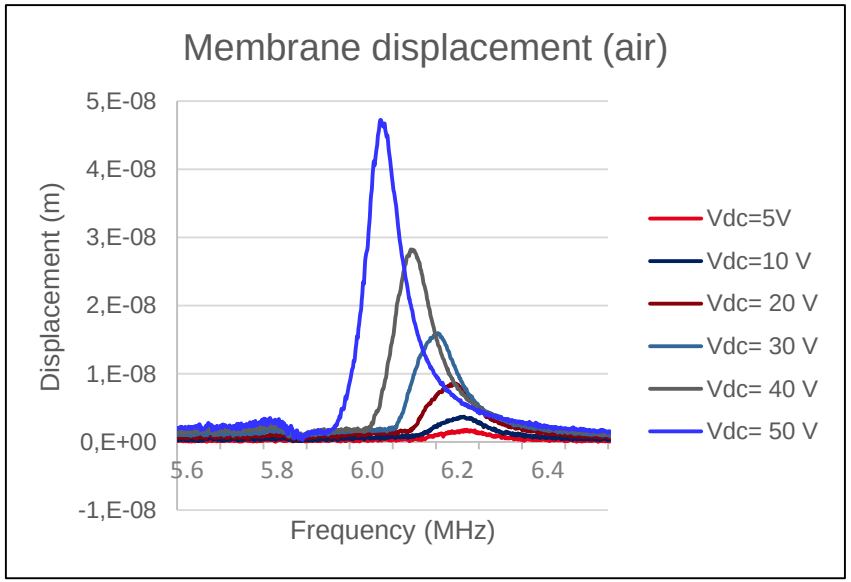


Wafer bonding process :

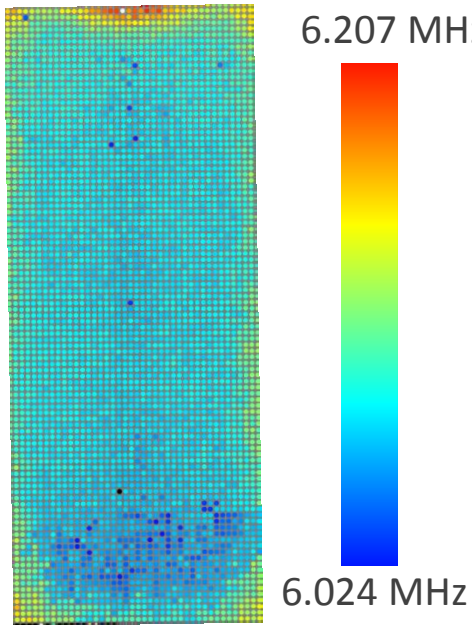
- **Mono-Si**
- **Si Thickness between 200 – 1500 nm**
  3σ < 5 nm on 8'' scale (end of process)
- **Gap between 50 and 1000 nm**
  3σ < 10 nm on 8'' scale

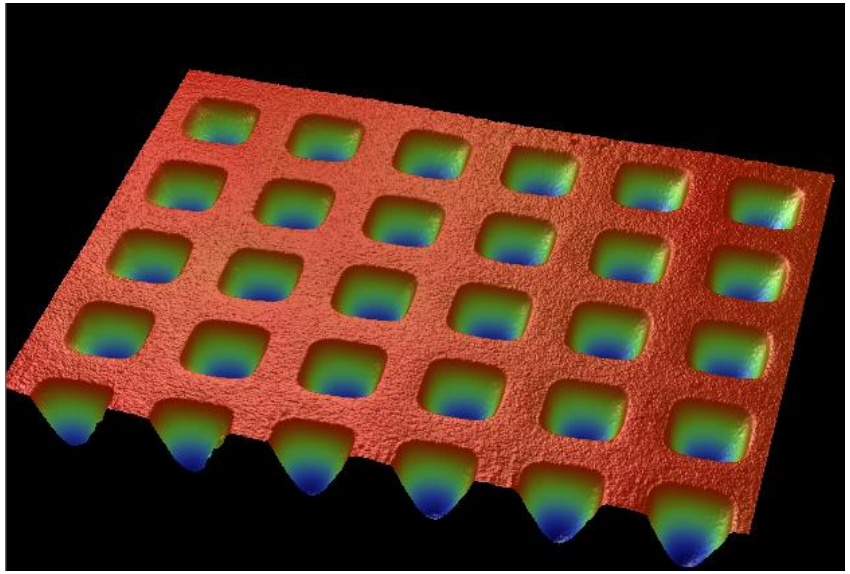
CMUT @ LETI

- Multi-scale characterization
  - Static characterization (DHM)
  - Mechanical response (DHM, Vibrometer)
  - Electrical response (Impedance analyzer)

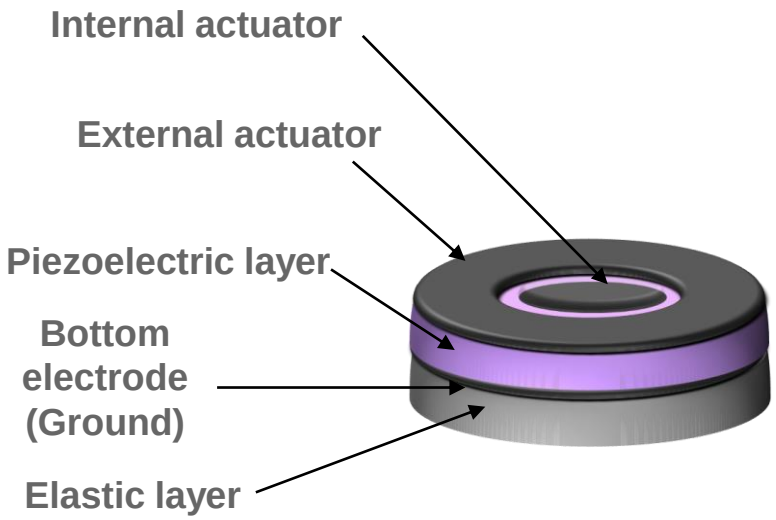


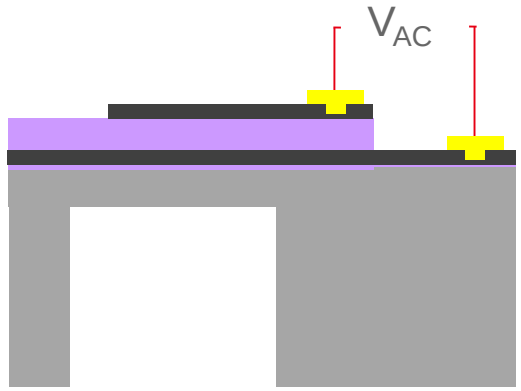
Mapping of a 126 x 44 cMUT array (resonance frequency)



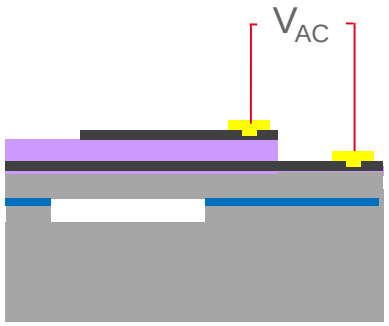


PIEZOELECTRIC MICROMACHINED ULTRASOUND TRANSDUCER (PMUT)

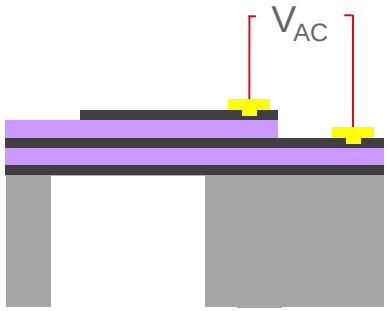




piezoelectric actuation and mechanical clamping
→ Flexural motion



Unimorph structure (no DRIE etching)

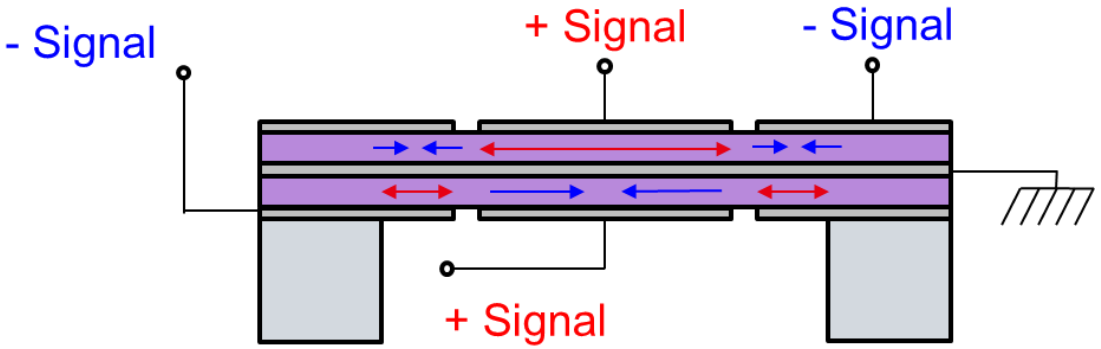


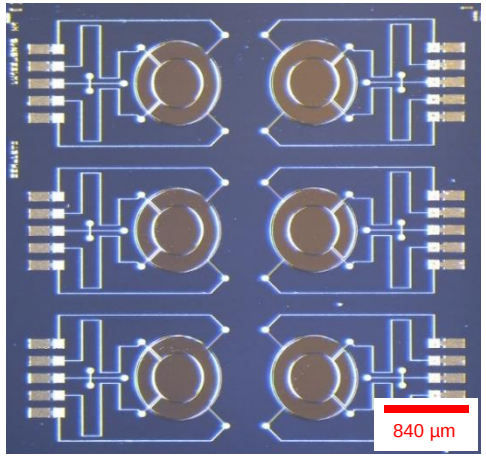
Bimorph structure (AlN)

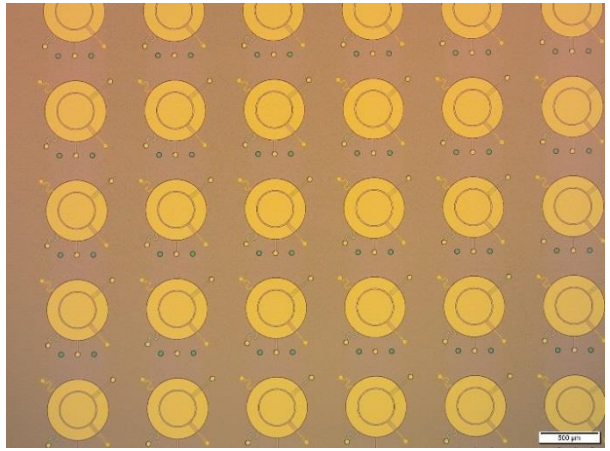
	PZT	AlN
E (Gpa)	82	330
ν	0.24	0.39
ρ (kg/m³)	7500	3255
ε_r	1400	10
$\lvert e_{31,eff} \rvert$ (C/m²)	22	0.9
Breakdown field (V/µm)	90	390
Technology	*Sol-gel deposition*	*Sputtering*

ALN-BASED BIMORPH PMUT @ LETI

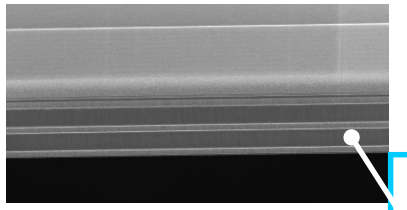
pMUT array with multi-electrode schemes

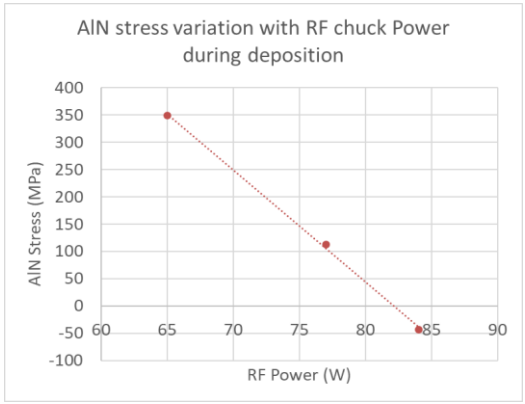


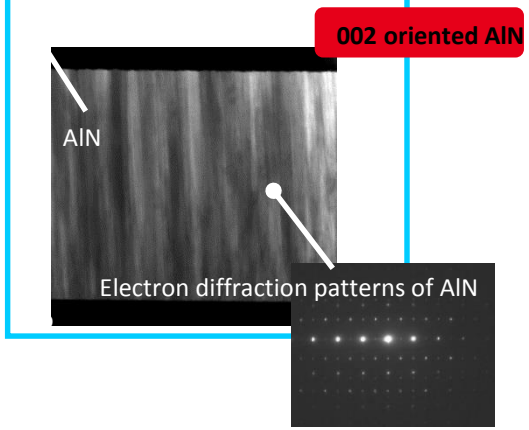


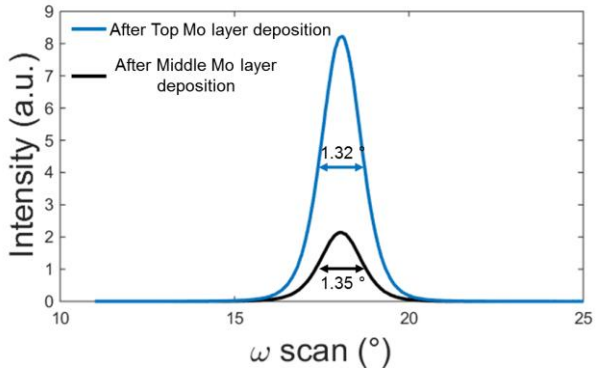


Characterization of AlN layers

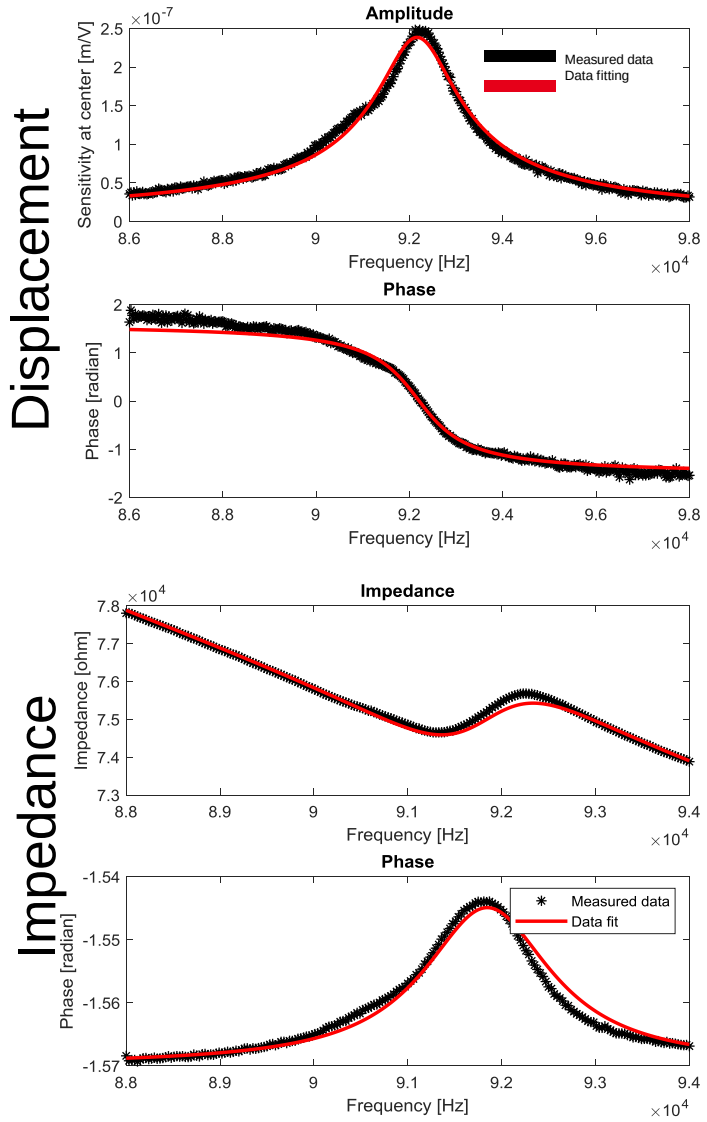


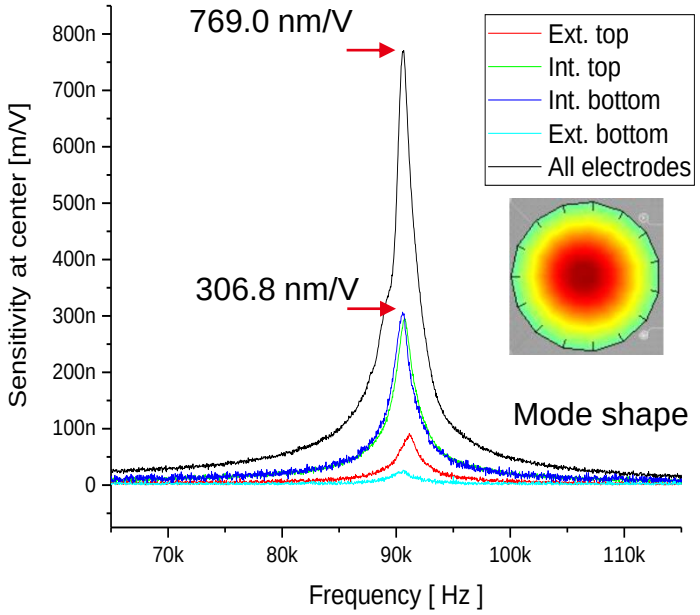




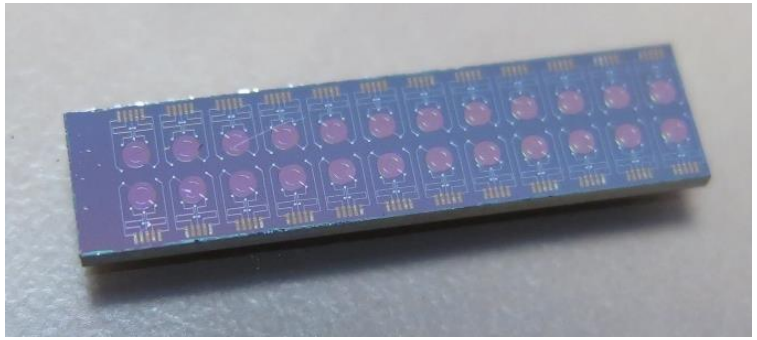


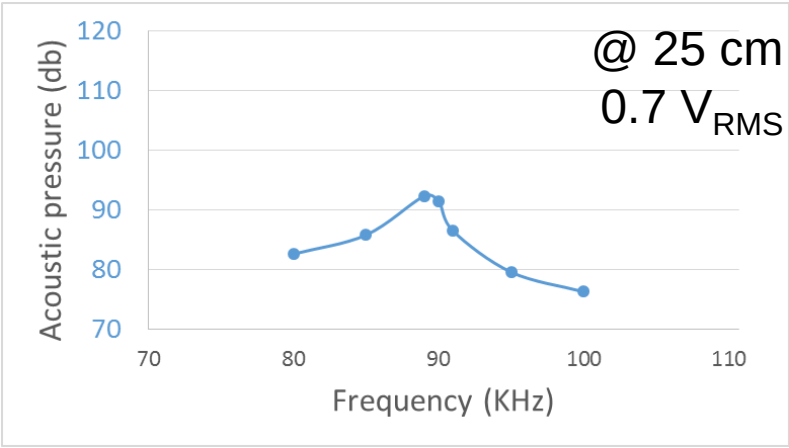
ALN-BASED BIMORPH PMUT @ LETI

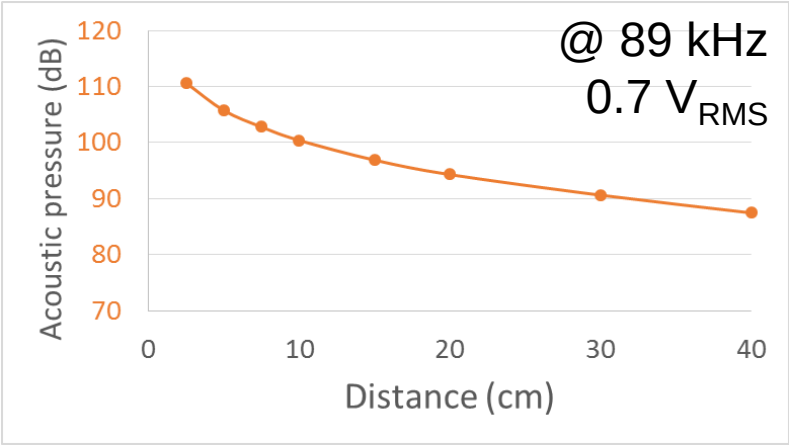




AlN-based multi-electrode scheme partially compensate the low piezo-electric coefficient

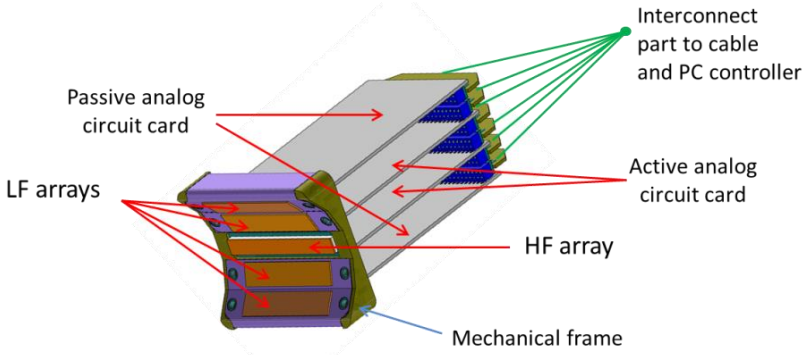


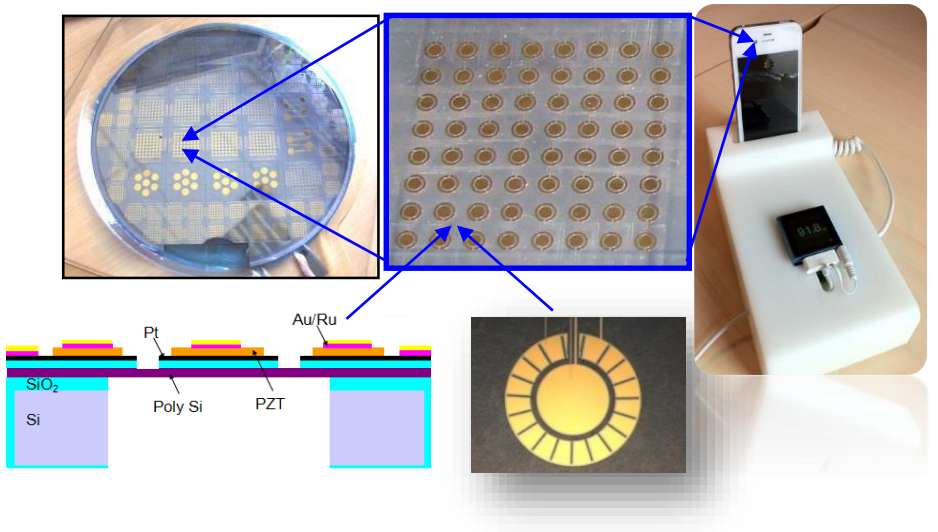




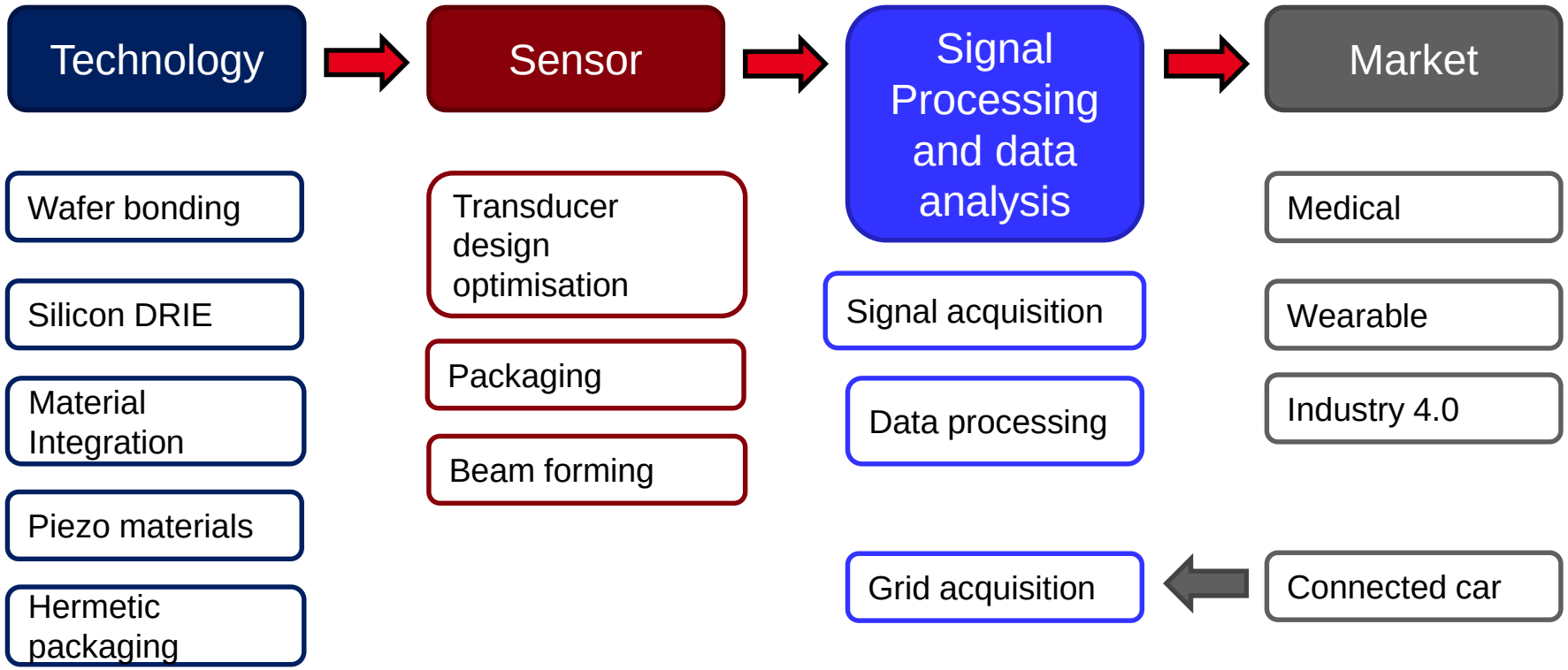
CONCLUSION : PMUT / CMUT @ LETI

- ✓ Complementary pMUT and cMUT technologies for different applications
- ✓ 8” piezo-MEMS pilot line (PZT, AlN, …) @ LETI
- ✓ Wide range of characterization tools : DHM, vibrometer, automatic 8” prober, acoustic setup
- ✓ Piezoelectric material at the state of the art



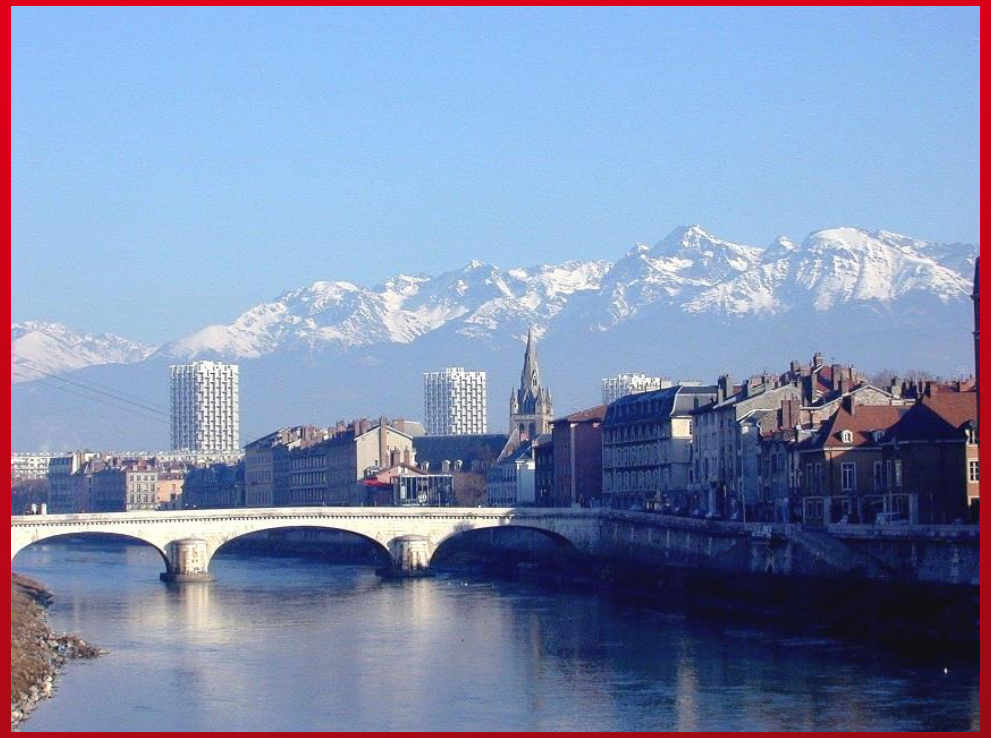


LETI ASSETS ON ULTRASONIC SENSORS



- Piezoelectric material integration on 200 mm wafers
- MEMS state of the art 200 mm line
- Strong background in phase array system
- Unique experience in imagers–from pixel to image analysis
- Assets in data fusion
- Embedded Software expertise

Thank you for your attention



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