

# Capacitive Micro machined Ultrasonic Transducers arrays (CMUTs) for Structural Health Monitoring (SHM).

Journée nationale contrôle sante et monitoring des structures March 12, 2020, Paris, France

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#### Context

- Capacitive and piezoelectric sensors
- Problematic

**Characterisation techniques** 

- Electrical characterisation
- Acoustical Characterisation

#### **Experimental results**

- Tensile test on flat /epoxy
- Signal amplitude comparison
- Signal frequency comparison



Perspective





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- Maintenance is performed on immobilized devices
- Currently more than 25% of lifecycle costs are spent on inspection and reparation
- ✤ We develop acoustic instrumentation and technique for Structural Health Monitoring (SHM)
  - Detection of damage on real-time
  - Help for simulation validation
  - Collection of data
  - Predictive analysis







Size: little intrusive into the material

### ✤ High bandwidth





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- ✤ High bandwidth





Size: 10 mm diameter X 12 mm height

Size: 16 mm diameter X 1.6 mm height



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A-A



- Capacitive Micro machined Ultrasonic Transducer (CMUT):
  - 2.5 mm X 2.5 mm chip
  - 40 elementary cells
  - PCB 12 mm diameter for electrical contact
  - Wire bonded
  - Encapsulated on 16 mm diameter







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- Validation of ability of CMUT to detect Acoustic Emission (AE)
- Validation of the ability to have an electrical measurement
- Improvement and development of the electrical measuring system
- Identification of the best configuration in the choice of electrical parameters





• Improvement of the signal noise ratio (S/N) : hard and soft



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- Bias voltage is adjusted between 0V to collapse voltage
- We applied V<sub>AC</sub>=0.5V peak-to peak with a synthesizer function generator (Helwett Packard 3325 B
- We measured the maximum amplitude of CMUT-R100 with laser Polytec vibrometer
- ✤ Collapse voltage at 85 V
- ✤ We applied 80% of collapse voltage
- Bandwidth frequency between 300 KHz to 500 KHz



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- ✤ MTS Criterion machine equipped with 100 kN
- ✤ Load sensor control 0,1 mm/s axial
- ✤ 3 sensors are placed on flax /epoxy plate
- Streaming data of AE signal was recorded during 50 seconds





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- CMUT-R100 depicts an important AE activity compared with Micro-80/R
- ♦ At the end of tensile test, three transducers have the same amplitude of AE activity (80 dB)



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- ✤ CMUT-R100 shows an important AE frequency activity
- $\clubsuit$  The shape response of the three transducers is similar
- At the end of tensile test, the frequency response of CMUT-R100 is comparable to μ80 E and R



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- ✤ Miniaturisation of the capacitive transducer
  - Volume CMUT-V1: 2304 mm<sup>3</sup>
  - Volume CMUT-R100: 322 mm<sup>3</sup>



- ✤ Improvement of the detected signal
  - Amplitude CMUT-V1: 7 mV
  - Amplitude CMUT-R100: 30 mV



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- Improvement of signal noise ratio
- Increase number of elementary cell
- ✤ Acoustical mismatching
- ✤ Line impedance mismatching
- Study influence of diameter of electrode



• The goal is to reach S/N of CMUT-R100 to S/N of  $\mu$ 80/R





# Thank you for your attention

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### <sup>2</sup>Travaux 2019-2020 : Etude de la réponse acoustique d'une membrane en fonction du couplage



Le signal reçu peut être divisé par deux dans certain cas



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### <sup>24</sup>Travaux 2018-2019 : Premier essai sur éprouvette (Aluminium) 1V





### <sup>2</sup>Travaux 2018-2019 : Premier essai sur éprouvette (Aluminium) 1V



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### <sup>2</sup>Travaux 2019-2020 : Premier essai sur éprouvette (Aluminium) 200mV





### <sup>2</sup>Travaux 2019-2020 : Premier essai sur éprouvette (Aluminium) 200mV (après filtre Matlab)



