Smart detection system based on piezo-composite transducers for SHM applications

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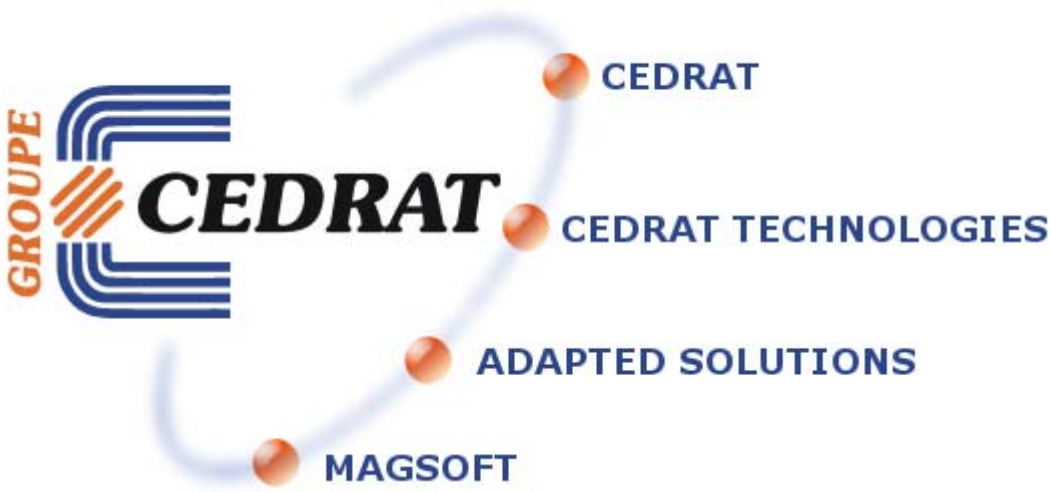
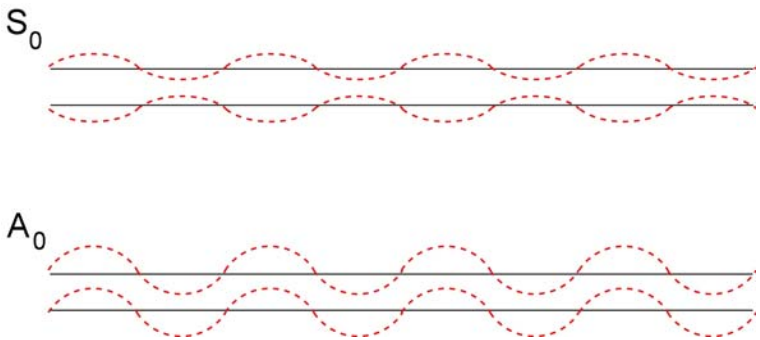


Presentation plan

- Problematic in SHM detection schemes
- Prototyping
- Electronics
- Testing
- Conclusion

Problematic in SHM detection schemes

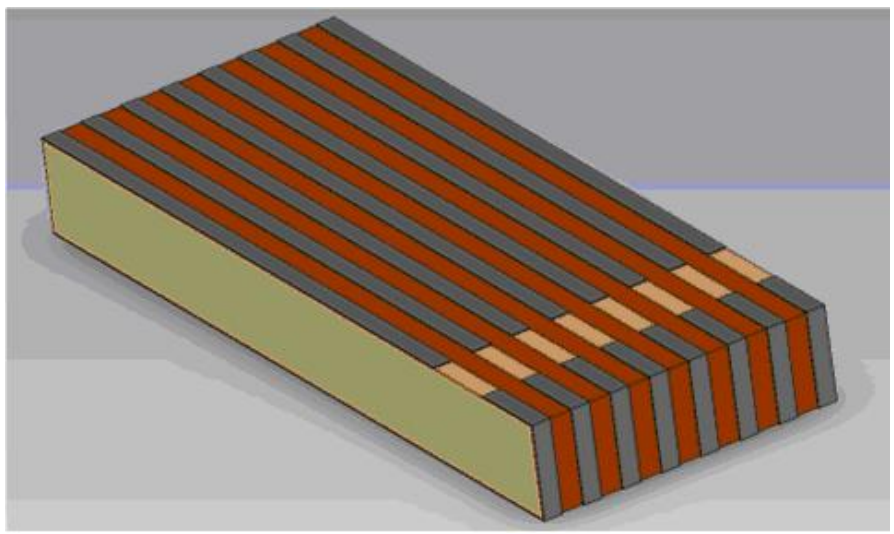
- Emission and reception of accoustic waves with piezo-electrical patches and study the propagation of the waves into the structure to detect a defect (crack, delamination,...)
- Burden of signal processing: multi-echoes & multi modes of propagation.
- For frequencies around several 100kHz, S_0 (symmetrical) and A_0 (anti-symmetrical) modes:



- Strong interest in S_0 mode, fastest mode and more sensitive to defects.
- Need for mode and direction selectivity of the waves, to focus on the S_0 mode.

Prototyping - Concept

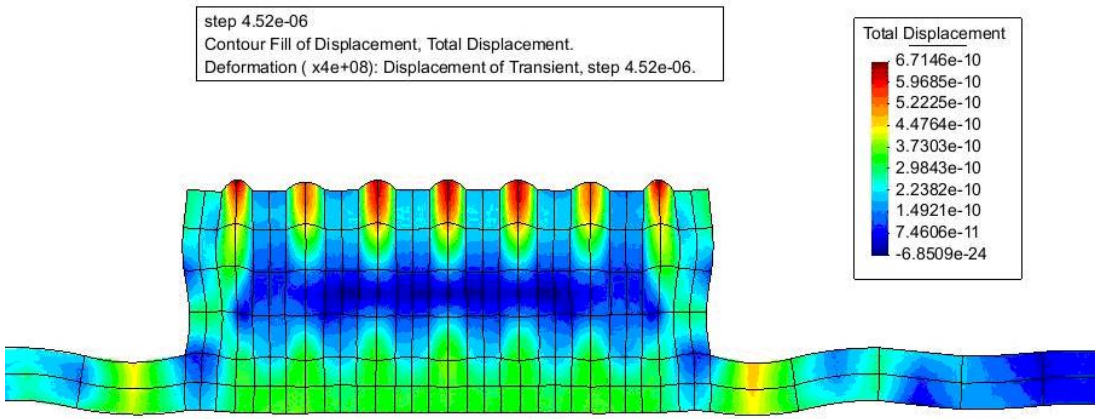
- 1-D array of piezo-patches transducers with fixed pitch
- Several signals received or emitted for several known positions
  - Possibility to distinguish waves propagating at different speeds



- Based on velocity of the selected mode => simple signal processing to amplify this mode at emission and reception

Prototyping – Modelling and simulation

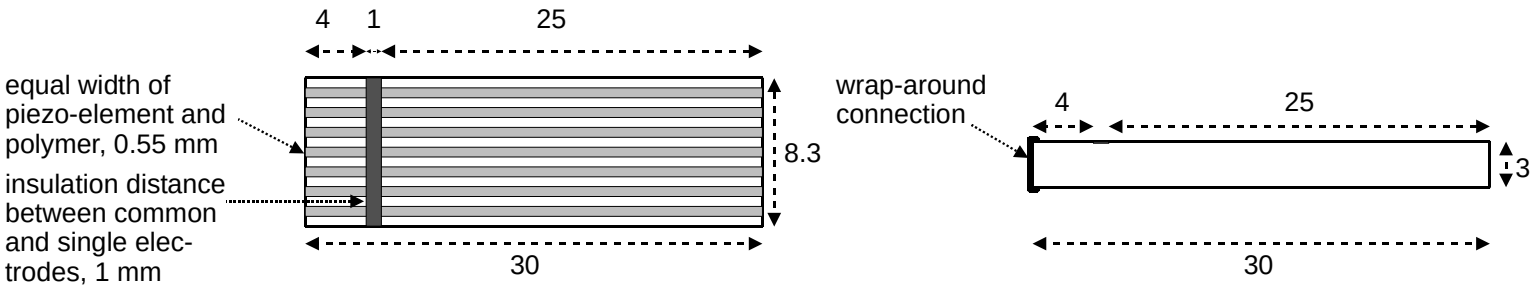
- Designed for resonance frequency around 500KHz
- 8 elements, 1mm pitch
- FEM model with ATILA:



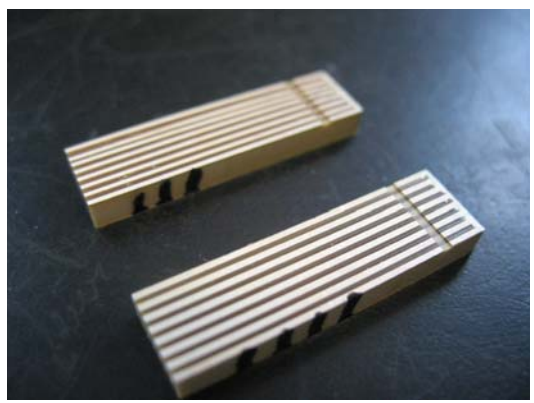
- Simulations
  - Theoretical feasibility of the direction and mode selectivity at reception
  - The principle can be reversed to obtain the mode and direction selectivity at emission

Prototyping – Manufacturing

- General features:

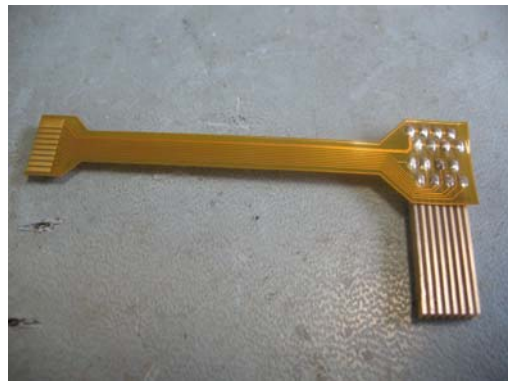


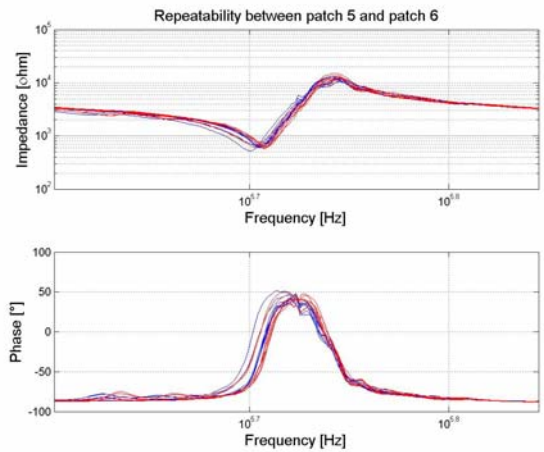
- Manufacturing of the prototypes by Ferroperm:

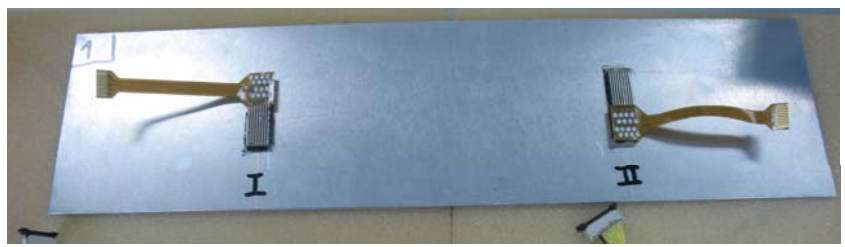


Prototyping – Integration

- Resonance 530KHz in reality
  - Not far from the modelling
  - Fine repeatability between patches and elements



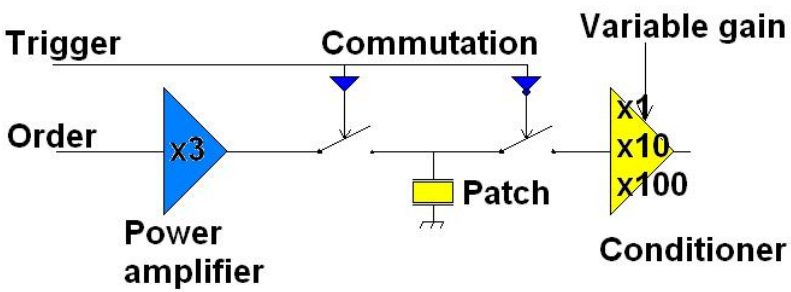


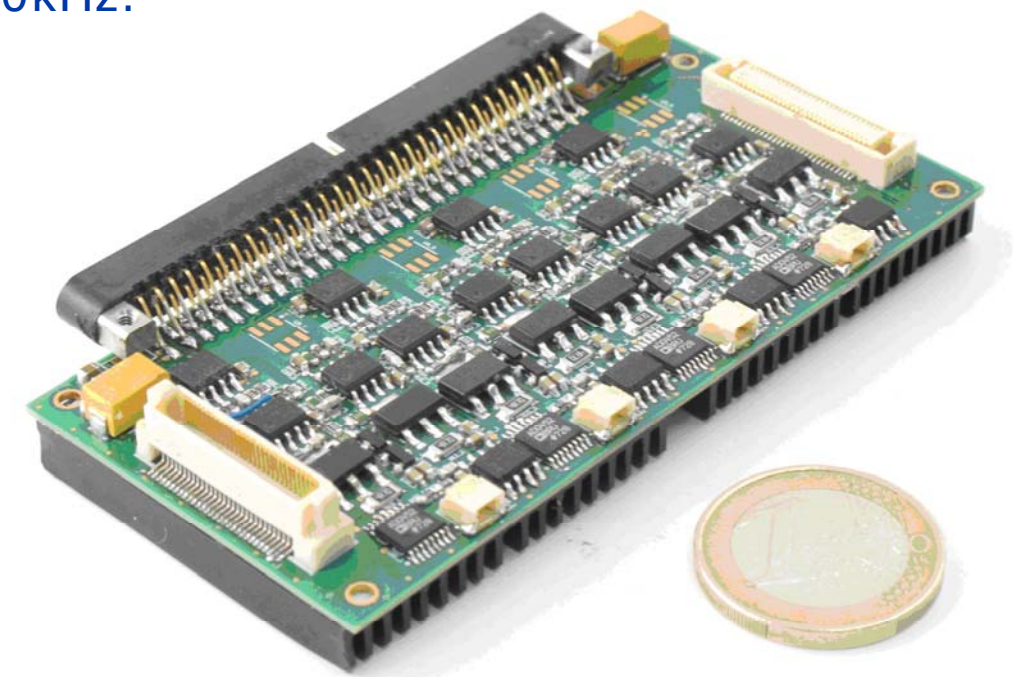


- Flex PCB for connections
- Bonding on aluminium test plates
  - 2 patches per plate, emitter & receiver

Electronics

- Embedded / daughter board with 4 independent channels:
  - Pulsecho capability
  - 30Vpp excitation
  - Bandwidth higher than 500kHz.
  - Drives loads up to 10nF
  - Low-noise monitoring



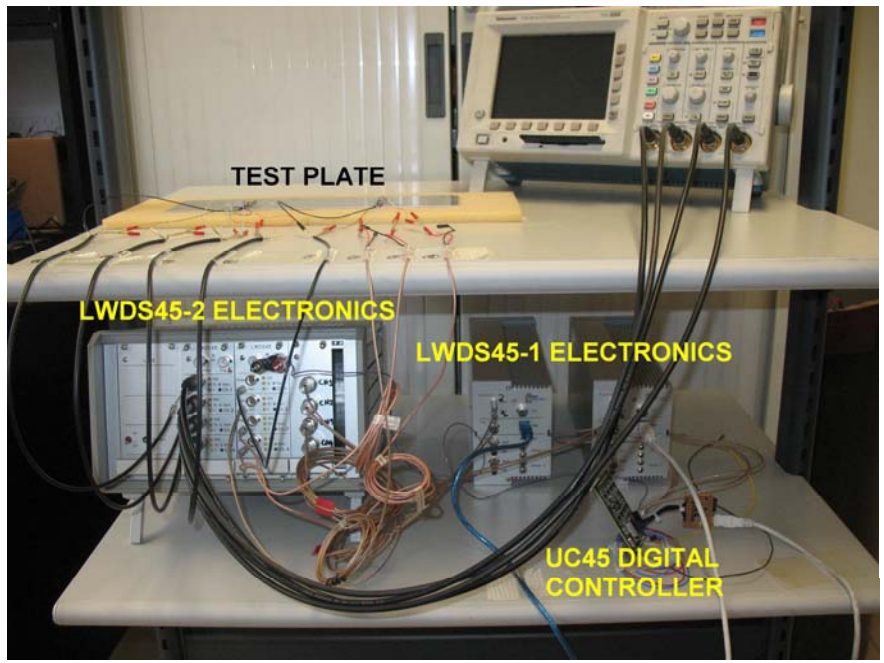


Electronics - Continued

- LWDS45-2 : User-friendly interface
  - Settable monitoring gain
  - Choice of emitting channel
  - Versatility and modularity

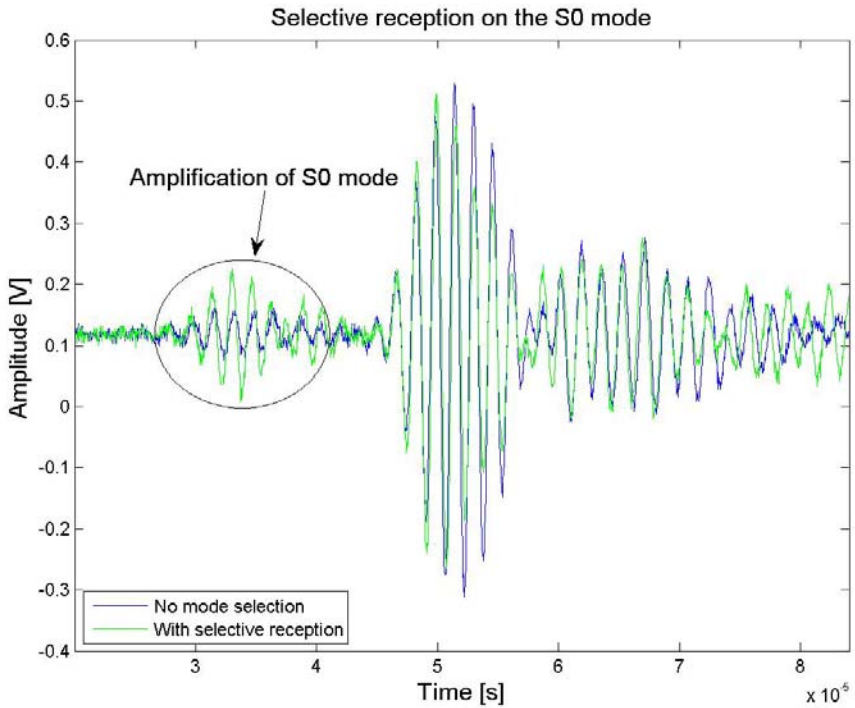
Testing - Test bench

- Test plate with 2 piezo-composites (elements paired)
- 2 LWDS45-2 in the rack
- 2 LWDS45-1 and a UC45 for signal generation
- USB link for online changing of emission parameters (phase and length of burst)
- 4-channels scope for monitoring / sampling signals



Testing – Selective reception

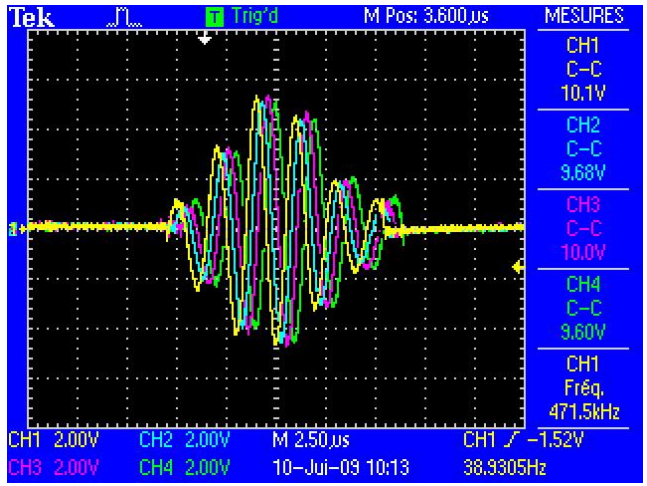
- Test of the selective reception technique on the S_0 mode:



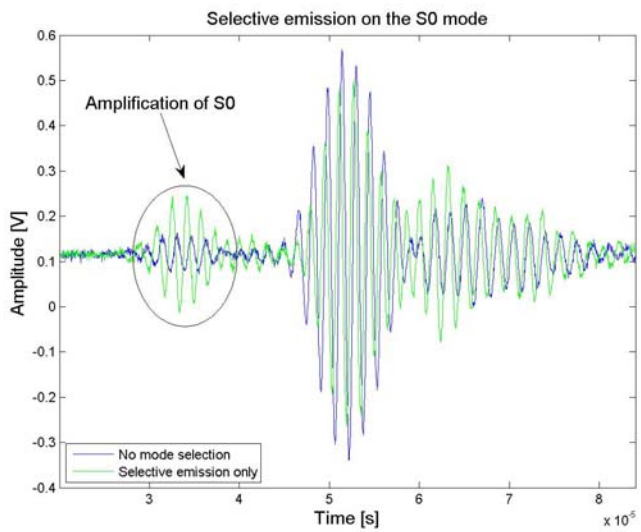
- S_0 mode is amplified thanks to the selective reception

Testing – Selective emission

- Selective emission obtained by reversing the principle applied for the selective reception:

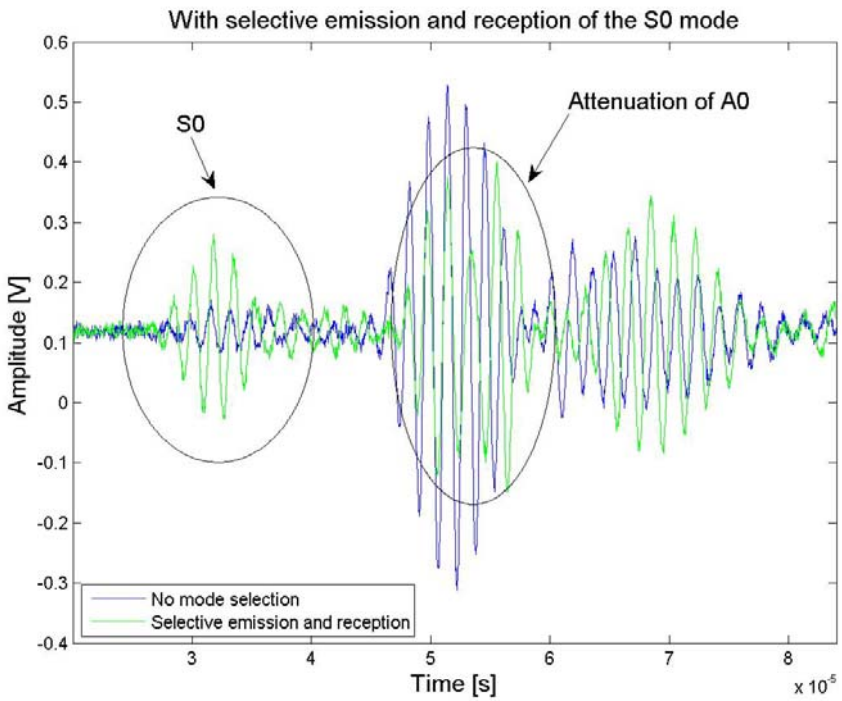


- Test of the selective emission on S_0 mode:
  - S_0 mode is amplified with selective emission



Testing – Combination of selective techniques

- Combination of both techniques to achieve higher performance:



- S_0 mode is amplified and the A_0 mode is attenuated

Conclusion

- Piezo-composites can be used as smart transducers
- Achieve selective emission and reception of the Lamb waves
- The S_0 mode can be greatly amplified
- Simple signal processing required

THANK YOU

QUESTIONS ?