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Evaluating Techniques for Joining Piezo-Electric Elements on Test Structures for Performing Vibration-Based Measurement Methods

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Motivation & Goal

- Vibration-based measurement methods require vibration coupling between piezo-electric element and test structure
- State of the art: piezo-electric element bonded to structure by using an adhesive (e.g. 2-component epoxy adhesive)
  + Good vibration transmission
  + Tried and tested many times in literature
  - Irreversible connection
  - Preparation of the joining surface and curing time
  - Limits flexibility and scope of the test method

- Development and investigation of alternative connection concepts
- Reversible connections, higher flexibility, reuse of piezo element
- Recommendation of a joining technique based on application

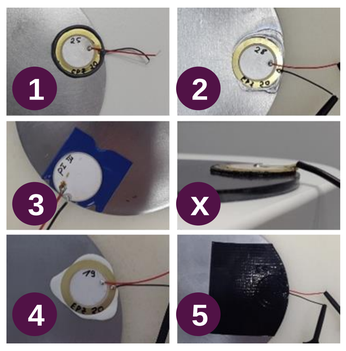
Requirements to joining

Transferring deformations of piezo element	■ Deformations in the order of nanometers ■ Transmission for all frequencies from 1 to 45 kHz
Influencing vibration characteristics	■ As little influence as possible due to connection ■ Vibration behavior characterized by properties of structure
Sensitivity	■ High sensitivity of electrical impedance to changes in mechanical impedance of structure
Attaching piezo element	■ Fast, intuitive, short preparation time, high repeatability
Material, geometry and surface of structure	■ Connection suitable for diverse combinations of material, geometry and surface finish of the structure
Ambient temperature	■ Increased temperatures possible, up to maximum operating temperature of piezo element (half of Curie Temperature)
Lifetime of connection	■ High number of load cycles endured ■ Ideally service life corresponds to that of piezo element
Reversibility	■ Reversible removal and reuse of the element ■ Piezo element and structure will not be damaged
Costs per connection	■ Below cost for piezo element

Concepts for Joining

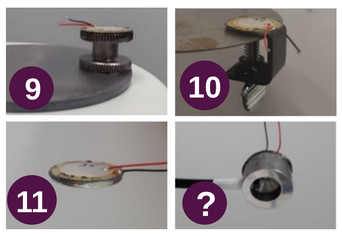
- New or further development of concepts based on state of the art
- Collecting ideas from literature research and brainstorming

Form fit



Friction coupling

Adapter concept



X No recommendation based on results
? Promising but improvements needed

Experimental Design

- Measurement setup based on Electromechanical Impedance (EMI)
- High- and Low-Cost piezo-electric elements
- Test structures: Blanks made of steel and polystyrene
- For measurement blanks positioned on foam (free storage)
- Obtaining impedance spectra from every joining technique
- Comparison with reference method (2-component epoxy adhesive)
- Evaluation of joining techniques with regard to the fulfillment of the defined requirements

Conclusion

- Decision diagram derived from experimental results
- Selection of suitable joining technique for different applications
- Force-fit joints only suitable for lower frequency range (< 15 kHz)
- Limited repeatability of reversible methods
- Drift of Impedance spectra with repeated measurement

Application-based joining