Simplified in-cylinder thin-films and direct contacting by laser welding

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Closed loop control of the combustion process based on real-time measurement of in-cylinder pressure sensors is a key technology for the reduction of emissions caused by combustion engines and the most efficient usage of fuels.

High temperatures, vibrations and the need for high temporal resolution place special requirements on in-cylinder pressure sensors and on the electrical contacts of the sensor element. In combination with the given small geometry and the required low production costs, high reliability and long-term stability, this represents a special challenge. A chromium based thin-film and an experimental laser welding are tested without using moving parts.

Contacting by laser welding

- Experimental laser welding used on all electrical contacts
- Additional nickel-based 150 nm thin film deposited on deformation-neutral zones allows for soldering or welding
- 150 µm wire coated with insulating material welded onto 210 nm thin film layer
- Tip of wire pre-melted by single laser shot to form a ball of 500 µm diameter
- Second shot causes wire and thin-film to fuse

→ Tight joint without destroying insulation layer, typically resisting 4 N shear force

Results

- 5 pressure sensors with variations and 1 temperature sensor
  ➔ Predictions verified by test results
  ➔ High sensitivities above 20 mV/V
  ➔ Promising first results
- Temperatures up to 200 °C at sensing element, depending on coolant temperature and engine load
  ➔ Laser contacting and prototypes reliable so far with >200 h of testing
  ➔ Improvement of signal quality likely by tweaking thin-film process parameter

Conclusions & Outlook

- Sensor concept looks promising
- Long-term evaluation in progress
- Complete sensor package prototype including smart electronics in development
  ➔ Goal of the “Smart Combustion” HProfiUmt project
- Laser contacting will be explored in more detail in the future
  ➔ Interesting as no additional Material is used. Automation possible?
- Chromium thin-film has shown interesting behaviour
  ➔ Paper in preparation

Contact

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Simplified in-cylinder thin-films

Using highly-sensitive chromium thin-films and direct contacting by laser welding

Motivation

Closed loop control of the combustion process based on real-time measurement of in-cylinder pressure sensors is a key technology for the reduction of emissions caused by combustion engines and the most efficient usage of fuels.

High temperatures, vibrations and the need for high temporal resolution place special requirements on in-cylinder pressure sensors and on the electrical contacts of the sensor element. In combination with the given small geometry and the required low production costs, high reliability and long-term stability, this represents a special challenge. A chromium based thin-film and an experimental laser welding are tested without using moving parts.

Sensor concept

- Glow-plug at diesel engine can be exchanged for sensor
- Stainless-steel membrane as sensing element
- Simple turned steel part as carrier body, no moving parts
- Nominal pressure 250 bar
- Direct contact between membrane and combustion chamber
- Wheatstone bridge structured into chromium thin film sputtered onto a SiO₂ layer of insulation

Contacted sensing element with one wire per contact pad

Welding sample analysis on a SEM.
Blue: Wire doesn’t fuse with chromium thin-film.
Change: Reflection damaged thin-film, insulation ok.

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