Case Study

Improved High-Temperature Sensor Accuracy and Performance Stability using Aerosol Deposition

High temperature sensors are coated with a protective layer to secure performance. By coating them with α-Al_2O_3 using aerosol deposition long term stability is improved and measurement accuracy increased over the life span of the sensor.

Challenge

One way to manufacture high-temperature sensors for temperature ranges up to 850 °C is to use Pt electrodes. These electrodes are printed on ceramics and need a sealant to protect them from the outside environment. However, the sealant tends to poison the electrode regarding its performance. An intermediate protective layer is therefore introduced. Ceramics are used for this, typically alumina (Al_2O_3).

State-of-the-art deposition technologies for Al_2O_3 create coatings made up from meta-stable Al_2O_3 compounds. As the sensor is heated up for the first time, the coating goes through several phase transitions until stable α-Al_2O_3 is formed at 1000 °C. Voids and cracks form in the coating due to density changes during the transitions. Subsequently, the coating's ability to protect the Pt-electrode from contact with the sealant material is diminished. (Fig. 3 and 4)

High-temperature sensor

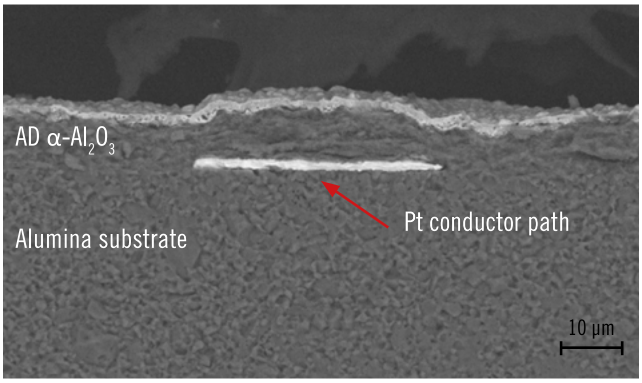
Approach

Pt-electrodes for high-temperature sensors were coated with Al_2O_3. One batch was coated in the conventional way. A second batch was coated using aerosol deposition resulting in an α-Al_2O_3 layer right from the start. After finalizing the devices both batches went through a heat treatment at 950 °C for 500 h and 12000 temperature cycles between 23 °C and 950 °C.

Results

Both results, after the heat treatment as well as after the temperature cycling, show that the performance of the devices coated with aerosol deposition are superior to the standard devices.

An estimation of the production costs shows that aerosol deposition is as cost competitive as the conventional deposition method for the Al_2O_3 protective layer.



SEM image of sensor cross section

Fig. 1: resistance drift

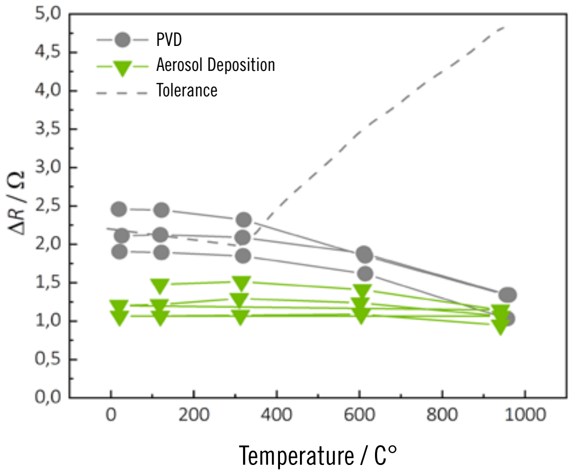


Fig. 2: temperature characteristics

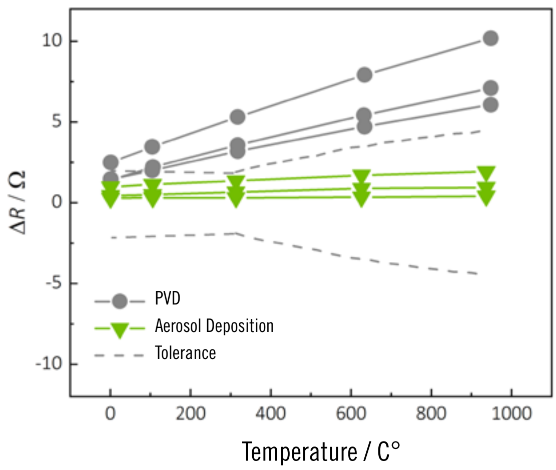


Fig. 1: The characteristic curve for resistance drift for Pt-sensors coated with aerosol deposition after long term tests (500h at 950 °C) shows a unique constancy from room temperature to 1000 °C within the tolerance band while outperforming standard PVD processed Pt-sensors in the temperature range between room temperature and 600 °C.

Fig. 2: The temperature characteristic curve for high temperature Pt-sensors after 12000 temperature cycles between room temperature and 950 °C shows no significant change in resistance for aerosol deposition processed sensors while standard PVD fabricated sensors are outside the tolerance range.

Fig. 3: Layer applied by Aerosol Deposition

Fig. 4: Cracks in layer applied by PVD

Conclusion

- α-Al_2O_3 coatings manufactured by aerosol deposition are suitable to form protective coatings between the Pt-electrode and the sealant material in high-temperature sensors.
- They improve the long-term stability of the device and increase the measurement accuracy over the live span.
- Aerosol deposition is the only coating technology that can produce α-Al_2O_3 layers directly without phase transitions or chemical reactions.
- The aerosol deposition based devices perform stably up to a temperature of 950 °C.

Interested? Contact us!

Heraeus High Performance Coatings
Heraeusstraße 12 – 14
63450 Hanau, Germany
E-mail: hpc@heraeus.com
www.heraeus-high-performance-coatings.com