PERFORMANCE OF LSPR HYDROGEN SENSORS IN VARIABLE HUMID CONDITIONS

David Tomecek[a], Iwan Darmadi[a], Christoph Langhammer[a]

[a]Chalmers University of Technology

e-mail: david.tomecek@chalmers.se

Abstract text

Since the decision to move to a more sustainable and greener economy, there has been a huge growth of interest in various hydrogen technologies. These include hydrogen gas sensors as they enable hydrogen to become a safe carbon-free energy vector. Safety hydrogen sensors can be based on various sensing principles.[1] LSPR hydrogen sensors have demonstrated great performance providing low LoD, fast responses, high selectivity, and poisoning resistance. However, their performance in ambient humidity conditions has not been properly studied and described so far.[2]

Therefore, this contribution presents a detailed description of their performance in situations with variable humidity. As a representative sensing material, we have chosen $Pd_{70}Au_{30}$ as it offers good sensitivity in low concentration region and hysteresis-free response characteristics. The sensors themselves were fabricated as nanodisk arrays using a hole mask colloidal lithography. The disk proportions were set to 210 x 25 nm (diameter x height). Their performance was quantified using standard sensor characteristics (LoD, response time, recovery time, and response stability in humid conditions defined in ISO 26142:2010 standard). The evaluation tests covered the relative humidity range of 0 – 80% (at 30 °C), sensor operation temperature range of 30 – 130 °C, and the H_2 concentration range of 0.06 – 1.3%.

We found out that the humidity significantly influences sensor signals and causes small negative responses if the sensors are exposed to low H_2 concentrations. These negative responses are an undesirable effect because they considerably increase sensor LoD (from 0.006% in dry conditions to ca. 1.1% in the relative humidity of 80%), but they can be mitigated by increasing sensor operation temperature. Increasing the temperature from 30 to 105 °C decreases the LoD back to ca 0.13% which is a sufficient value for the safety function. Besides this, we have shown that the sensors can pass the stringent humidity stability requirement of the ISO 26142:2010 standard down to the concentration of 0.28%.

References

(1) Hübert, T.; Boon-Brett, L.; Black, G.; Banach, U. Hydrogen Sensors – A Review. *Sensors Actuators B Chem.* **2011**, *157* (2), 329–352.

(2) Darmadi, I.; Nugroho, F. A. A.; Langhammer, C. High-Performance Nanostructured Palladium-Based Hydrogen Sensors—Current Limitations and Strategies for Their Mitigation. *ACS Sensors* **2020**, *5* (11), 3306–3327.

Picture of Author	Short Biography of Author
	Author was born in 1991 in Czech Republic. Nowadays, he works as a **postdoctoral researcher** in the group of Christoph Langhammer at Chalmers University of Technology**. Educational background:** **2020: PhD in Technical cybernetics**, UCT Prague, Dissertation thesis: "*Gas Sensors for Detection of Explosive Taggants and Pollutants in Air*" **2015: Master degree in Sensorics and cybernetics in chemistry**, UCT Pragues, Master thesis: "*Thin Layers of Organic Semiconductors for Chemical Sensors*"