Various sensing mechanisms on Pt atomic layer deposition loaded WO_3 gas sensors

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Loading semiconducting metal oxides with different noble metals like Pd, Au, or Pt is a way to improve the gas sensor performance and change the gas sensing mechanism [1-3]. Not only the type of the noble metal can change the sensing mechanism but also the employed loading method [3]. In case of Pt impregnation loaded WO_3 sensors, the Fermi-level control is dominating the sensing mechanism [2][4]. However, the impregnation method does not allow for a controlled, uniform distribution of the noble metal. Atomic layer deposition (ALD) is a convenient candidate for loading as it permits a control at atomic level of the loading process and by that of the deposited amounts of the noble metals [5]. In principle, it could allow even the deposition of separated single atoms and provide single reaction sites on the metal oxide surface. To date, no systematic investigation was performed and that is the goal of our work.

ALD Pt loaded WO_3 sensors with different numbers of cycles (2, 5, 10, 25 and 50) were prepared and characterized by means of scanning transmission electron microscopy (STEM) and x-ray photoelectron spectroscopy (XPS). Furthermore, DC resistance measurements were conducted to evaluate the sensor response to different test gases. Moreover, operando diffuse reflectance infrared Fourier transform (DRIFT) spectra were recorded in order to gain more knowledge about the surface chemistry. Investigations on differently Pt loaded samples indicate a change in the gas sensing mechanism depending on the number of the ALD cycles.

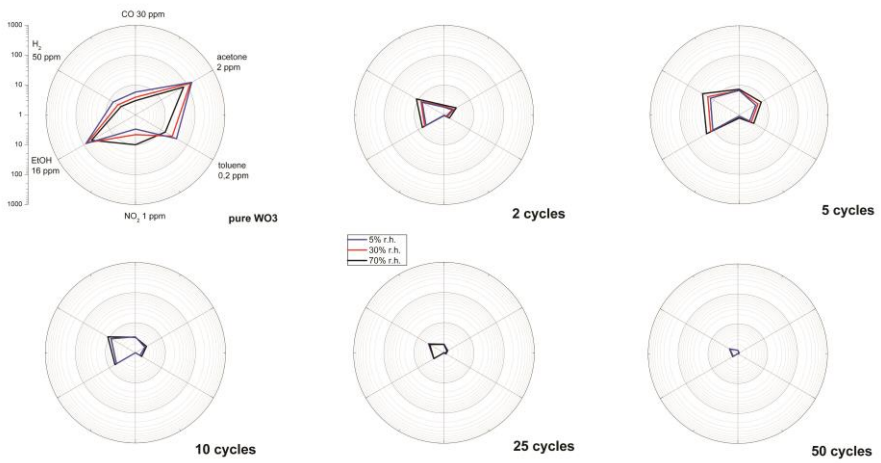

Fig. 1. Sensor profile of the Pt ALD loaded WO_3 gas sensors at 300 °C

[1] A. Staerz et al., “Rhodium Oxide Surface-Loaded Gas Sensors,” Nanomaterials, vol. 8, no. 11, p. 892, 2018.
[2] A. Staerz et al., “The effect of platinum loading on WO 3 based sensors,” Sensors Actuators, B Chem., vol. 291, no. February, pp. 378–384, 2019.
[3] N. Yamazoe, Y. Kurokawa, and T. Seiyama, “Effects of additives on semiconductor gas sensors,” Sensors and Actuators, vol. 4, no. C, pp. 283–289, 1983.
[4] A. Staerz et al., “Direct Microscopic Proof of the Fermi Level Pinning Gas-Sensing Mechanism: The Case of Platinum-Loaded WO3,” J. Phys. Chem. Lett., vol. 11, no. 1, pp. 166–171, 2020.
[5] C. Marichy, M. Bechelany, and N. Pinna, “Atomic layer deposition of nanostructured materials for energy and environmental applications,” Adv. Mater., vol. 24, no. 8, pp. 1017–1032, 2012.