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Room temperature hydrogen sensors compatible with CMOS technology: a necessary step for the coming renewable hydrogen economy

Abstract

Moving towards a new, renewable energy system based on green energy vectors such as hydrogen needs not only direct energy production and storage systems, but also the development of secondary components, such as highly sensitive hydrogen gas sensors integrated into mass devices that operate at ambient conditions (temperature, pressure). To this end, the Cottbus *Innovationscampus Elektronik und Mikrosensorik*(iCampµs) has been established at the end of 2019, which is focused on providing integrated sensor solutions to address high-tech requirements of future global challenges. In particular, our group, together with other research institutes and partners from the iCampµs, is working on the development of novel resistive hydrogen gas sensors operating at room temperature (RT) and based on CeO_2. By atomic layer deposition (ALD), 10 nm thin films of this active oxide are deposited on silicon-structured substrates (isolated by Al_2O_3 or SiO_2) compatible with complementary metal oxide semiconductor (CMOS) technology. This new configuration means moving a step forward in comparison to previous thick layer and conglomerate sensor systems in terms of integration and material deposition control.

However, beyond the applied soul of the project, important open questions remain that have to be answered to succeed. In order to decrease the operation temperature of CeO_2 below the typical window (200-1200 °C) [1] to RT the fundamentals of the CeO_2-atmosphere interaction must be understood [2]. Besides, unlike other approaches the ALD technique is well known to lead to amorphous and defective, non-stoichiometric layers. Moreover, the role of such defects must be clarified in terms of possible increase of the reactivity and further Ce^{4+}/Ce^{3+} conversion and subsequent changes in the electrical conductivity, which is used as the tracked parameter for the hydrogen sensing.

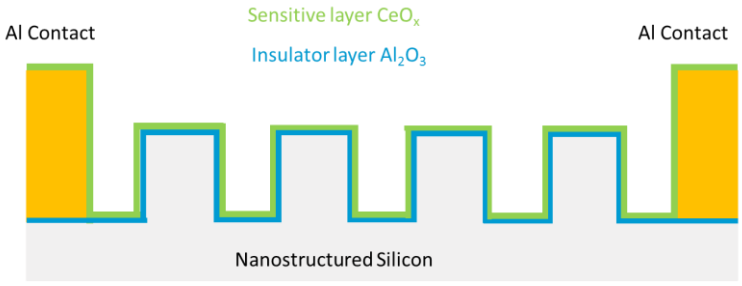

Figure 1. Scheme of the resistive CeO_2-based gas sensor. Both, Al_2O_3 and CeO_2 layers are deposited by ALD on nanostructured Si.

References:

[1] D. E. Motaunga, et. al.; Sens Actuator B; 254, 2018, 984-995

[2] K. Suzuki, H. Miyazaki, Y. Yuzuriha, Y. Maru, N. Izu; Sens Actuator B; 250, 2017, 617-622