Operando FTIR for surface reactivity studies on chemiresistive gas sensor

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The increasing demand for precise detection of gaseous molecules towards diverse applications, such as air quality monitoring, breath and health analyses or precision agriculture, has led to expanding research for high-performance semiconductor-based chemical sensors. Indeed, although these devices suffer from several unsolved drawbacks, such as the not well-defined selectivity, lack of stability and cross-sensitivity to humidity, they reach popularity thanks to their low cost of production, small size and ability to be easily integrated into microelectronic platforms. Besides, the employment of nanostructured materials in thick or thin sensing films has stimulated the development of chemiresistive gas sensors during the last two decades. Indeed, it has been demonstrated that a change of morphological characteristics in nanostructured materials, such as particle or crystallite size, leads to a change of active surface area and ultimately to the gas sensor sensitivity. Therefore, in the case of nanostructured materials, it becomes fundamental to deeply investigate the chemical phenomena occurring at the sensing film surfaces while analyzing the connected variations of the electronic structure and sensing characteristics. This correlation between surface chemistry and electronic properties has become critical in chemical sensors since it represents the core of the gas-detection mechanism. Among the arsenal of characterization tools available to support mechanistic proposals, Fourier-transform infrared spectroscopy (FTIR) spectroscopy has been known for several years for the investigation of surface chemistry of nanostructured materials. Accordingly, a variety of cells for in situ and operando spectroscopy have been developed over the years for transient catalytic investigations. However, efforts from a few research groups have been devoted to the development of a dedicated and optimized chemiresistive gas sensor testing chamber. Thus, a reliable sensing chamber must fulfil some basic requirements: it must be able to read-out the sensor as well as to heat the film, the electrical connections for the sensing electrodes and the heating element should not interfere with the simultaneous spectroscopic characterization and the chamber must allow direct treatments and high-temperature spectroscopy measurements in controllable gas atmospheres. We designed, fabricated, and validate a new gas sensing system that is easy to use and maintain. This can be employed with solid-state gas sensors with operating temperatures up to 650 °C, it is equipped with a precision stage for the alignment of the sample, and it is fully compatible with Harrick Scientific's diffuse reflection optics.

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