THICK AND THIN FILM GALLIUM AND TANTALUM OXYNITRIDE AND NITRIDE SENSORS FOR GAS DETECTION

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In the laboratory " Glasses and Ceramics " of the University of Rennes 1, research has been performed on oxynitrides, particularly ZnGeON[1] which is isostructural to ZnO, widely studied as gas sensor. Compounds having a tetrahedral structure are of interest because some of them have semi-conducting properties. Further studies on these materials have demonstrated[2,3] that zinc-germanium and cadmium-germanium oxynitrides are excellent sensing materials, especially for the detection of NH_3 and H_2S in ambient air.

Studies in progress on tantalum and gallium oxynitrides and nitrides show them to have promising detection properties. One of the aims of this work is to study the influence of the synthesis conditions on sensor properties. In this way, different processes were developed to optimise the detection properties of the sensors. Sol-gel and citrat methods were used in order to prepare very reactive powders. Various techniques were applied to characterise the materials. The variation of morphology and specific surface area of the powders was investigated by scanning electron microscopy (SEM) and BET method, respectively. The structural properties of the oxynitride and nitride compounds were determined by neutron and X-ray (XRD) diffraction analysis. The sensitive materials were deposited by screen-printing technology on alumina and sapphire substrates, resulting in layer thicknesses of 10-20 µm. As shown in Fig. 1 for gallium oxynitride (GaON) the thick layers exhibit macroporosity allowing a good diffusion of the gas into the sensitive layers.

Figure 2 shows the response of a GaON sensor to ethanol and CO in air at different humidities. The sensor exhibits a strong signal towards ethanol with a resistance decrease of approximately a magnitude. Additionaly to a short response time (t_{90}<1min) the signal recovery is complete after exposition to ethanol. This indicates a reversible surface chemistry reaction with fast adsorption and desorption of the analyte. The sensor signal to CO is less strong. Still, the clean slope, short response time (t_{90}<2min) and complete signal recovery encourages further studies. It is interesting to note that ethanol decreases the sensor resistance while CO increases it, contrarily to what can be observed with well-known materials such as SnO_2[4]. Humidity has a small influence on the signal baseline as well as on the signal to ethanol.

A further aim of this work is to investigate TaON and Ta_3N_5 thin film sensors. They were grown on sapphire substrates by pulsed laser deposition using a XeCl (λ = 308 nm) excimer laser. Several characterisation techniques were applied to the samples. The structural properties of the films were studied by XRD, their surface morphology was observed by SEM and their compositions were determined by X-ray Photoemission Spectroscopy (XPS). Comparative electrical studies are in progress between thick and thin film TaON and Ta_3N_5 sensors.

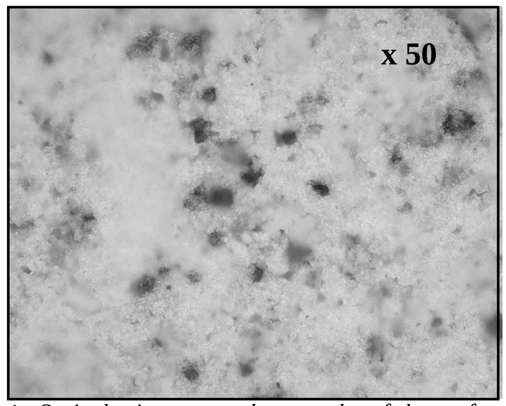

Figure 1: Optical microscope photography of the surface of a gallium oxynitride thick layer deposited by screen-printing on sapphire substrate.

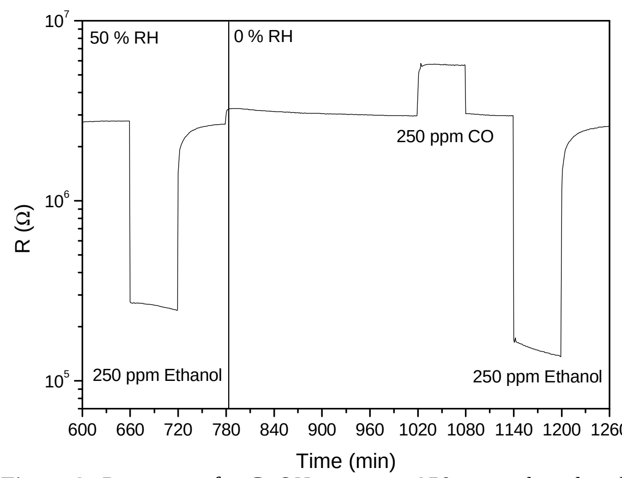

Figure 2: Response of a GaON sensor to 250 ppm ethanol and to 250 ppm CO, at 0 % and 50 % relative humidity in synthetic air. Operating temperature: 300°C.

References:

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