HYDROGEN DETECTOR BASED ON GaN NANOCONES

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Abstract. The photoelectrochemical etching techniques was used for uniform cone-like nanotexturization of MOCVD-grown GaN epilayers. A gas sensor was fabricated on nanotexturized layers and tested in hydrogen. The sensor exhibited a linear sensitivity in the range from 0.1 to 1.0 %, fast response and recovery times. It operates at temperatures up to 600°C, the minimum detected hydrogen concentration being 0.01%.

GaN is known as a very chemically stable material which can operate at high temperatures, thus making it a suitable candidate for the fabrication of solid state gas sensors. The usual structures for the detection of different gases at present are Schottky or FETs [1 -6], where catalytic properties of Pt, Pd or Rh are used for the purpose of changing semiconductor surface potential. The disadvantage in use of these structures is their degradation at high temperatures.

In this paper, we demonstrate that using GaN nanocone morphology obtained by photo electrochemical etching, it is possible to obtain very stable and easy in manufacturing gas sensors, in particular for hydrogen detection.

The GaN layers used in our experiments were grown by low-pressure metalorganic chemical-vapor deposition (MOCVD) on (0001) *c*-plane sapphire. A buffer layer of about 25-nm-thick GaN was first grown at 510°C. Subsequently a 0.5-μm-thick *n*-GaN followed by a Si-doped n^+-GaN film and a top *n*-GaN layer with 2.0 μm thickness each were grown at the temperature 1100°C. The concentration of free electrons in the top *n*-GaN layer was 1.7×10^{17} cm^{-3}, and Ti/Au (50/150 nm) ohmic contacts were deposited on top GaN by e-beam evaporation.

The photoelectrochemical (PEC) process was performed in a non agitated 0.5 M of KOH during 10 minutes with no bias applied between the sample and counter electrode. The UV radiation was provided by a 350 W Hg lamp. The morphology of the etched sample is presented in Figure 1.

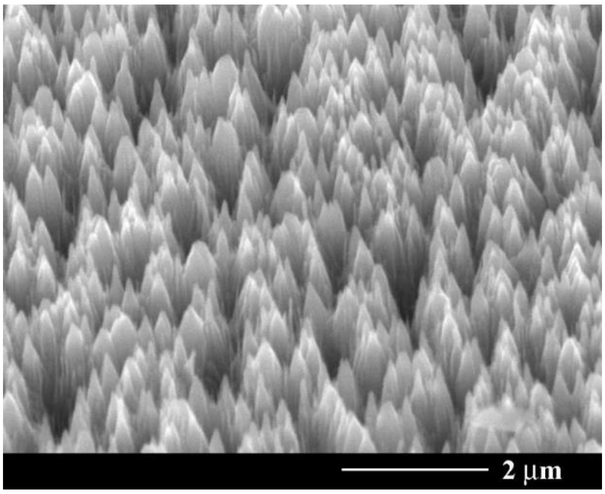

Fig.1 The cone-like morphology of GaN based gas sensor suitable for hydrogen detection

The gas sensitivity measurements show that the sensitivity dependence upon temperature exhibits two maxima, one at 300°C, and another one above 500°C (Fig.2.a), as well as a linear dependence of sensitivity versus hydrogen concentration in the range from 0.1 to 1 % at 300°C (Fig.2.b). The saturation level of sensitivity appears at around 30 % of hydrogen concentration, and does not exceed 80 %.

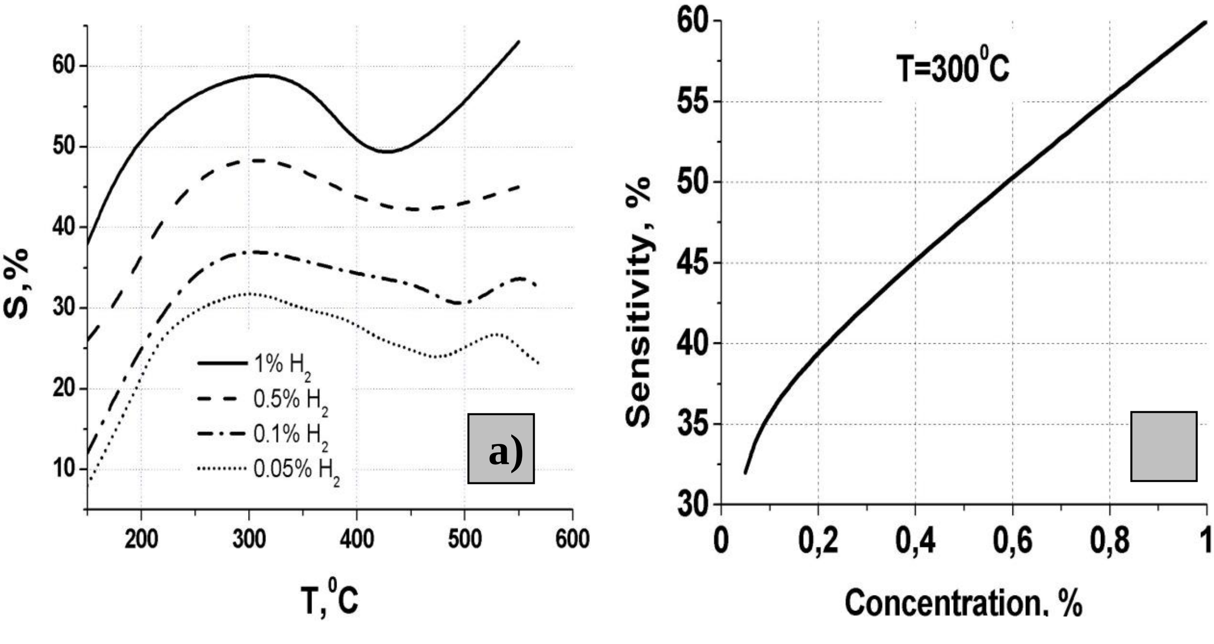

Fig.2. Sensitivity dependence versus temperature (a) and concentration

The response and recovery times does not exceed 3 seconds at 300°C, as can be seen from Figure 3.

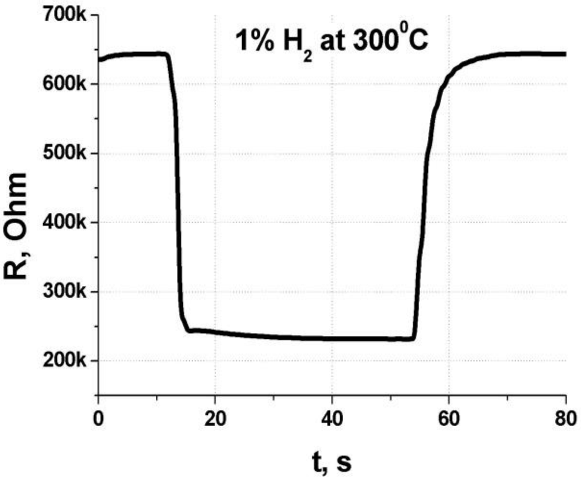

Fig.3 The change of sensor resistance in time.

A model for explaining the gas sensitivity of nanostructured GaN layers is proposed. We present a comparison of the obtained results with the literature data published previously.

CONCLUSION

In this article we demonstrate the potential use of GaN photo-electrochemically etched epilayers for the detection of hydrogen. The optimum working temperature was found to be as low as 300°C, where the sensitivity reaches its maximum value and the sensor exhibits a linear dependence in the range from 0.1 to 1.0 %. The thermal and chemical stability as well as the cost-effective technology predict for the elaborated GaN based gas sensor large applications for hydrogen detection.

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