

Supporting Information

Response of Gallium Nitride Chemiresistors to Carbon Monoxide is due to Oxygen Contamination

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1. GaN synthesis and fabrication of sensing layers

GaN was synthesized by the nitridation of commercial gallium oxide (β -Ga₂O₃) in dry ammonia at 900 °C over 24 h.¹ The as-synthesized GaN powder was screen-printed on alumina substrates provided with interdigitated Pt electrodes—for the readout of the electrical properties -on the front side and Pt heater - for the operation at well controlled temperatures -on the back side. To obtain a continuous sensing layer on the substrate, as-synthesized GaN powder was mixed with an organic compound (1,2-propanediol) and then ball-milled to obtain homogenous paste. The paste was pressed through the holes of a screen onto the alumina substrate. After screen printing the substrate coated with powder was kept at room temperature for 12 h. Finally the sensors underwent a thermal treatment under dry nitrogen flowing atmosphere in a moving belt oven (400–600 °C). A post-deposition ammonia treatment of the GaN screen-printed sensors was performed under dry ammonia at 800 °C for 6 h.

The substrate used for the deposition of sensing material is consisting of planar Al₂O₃ substrate with Pt-electrodes on the front side for measuring the sensor resistance and a Pt-heater on the backside to heat the sensor at the temperature of interest (Figure s3). The electrodes have an interdigitated structure to allow measuring resistances on a small area.

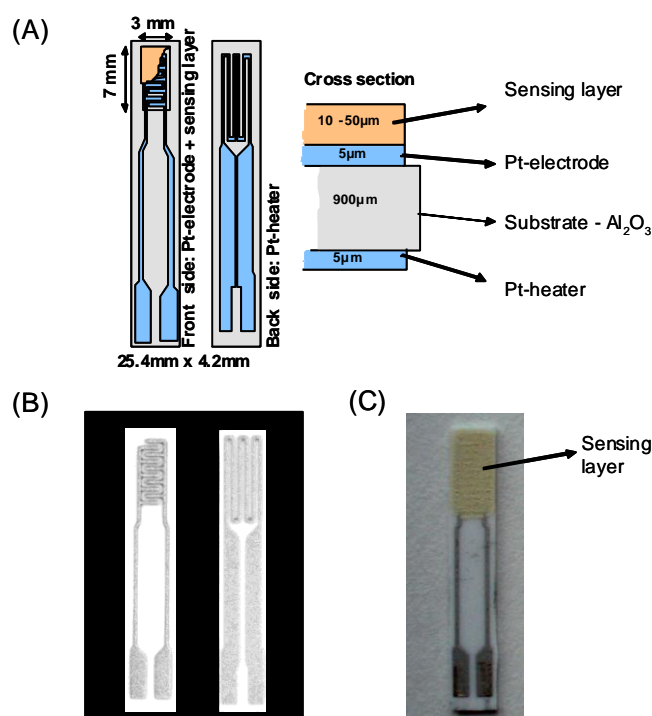


Figure s3. Gas sensor substrates: (A) layout of planar alumina substrate with Pt-electrodes on the front side and Pt-heater on the backside, (B) actual sensor support, (C) GaN layer (screen-printed) on the front side of support.

2. Characterization methods

X-ray powder diffraction data were collected on a D8 Advance diffractometer (Bruker, USA) with Cu K α radiation in the reflection scanning mode in the 2θ range of 25–80°. The nitrogen and oxygen content in GaN powders before and after additional ammonia treatment was measured with N/O analyzer (Leco, Type TC-436) using a hot gas extraction method.

Transmission electron microscopy (TEM) measurements were performed on powdered samples using an JEOL JEM2100F instrument (JEOL, Tokyo, Japan) operating at an acceleration voltage of 200 kV (wavelength $\lambda=2.51$ pm) in order to distinguish the crystal structure and particle size. EDS were recorded using an Oxford X-MAX 80 silicon drift detector (Oxford Instruments Nanoanalysis, High Wycombe, United Kingdom) attached to the JEM2100F. For the TEM sample preparation, the powders were dispersed in methanol (high purity methanol

99.8%, Sigma-Aldrich Co.) utilizing an ultrasonic bath and a small droplet of the suspension was placed on a holey carbon (Cu) grid. Upon drying, the samples were lightly coated with carbon to avoid charging under the electron beam.

Untreated- and ammonia treated-as-synthesized-GaN based gas sensors were mounted in a gas chamber which is connected to a computer controlled gas mixing system. Sensing performance was tested in an almost oxygen-free gas atmosphere (< 3 ppm; below the detection limit of the oxygen gas analyzer ZIROX SGM). The GaN sensors were exposed to CO (10, 20, and 120 ppm) for two hours in dry nitrogen (Type 5.5) in a flow of 500 sccm at an operation temperature of 350 and 530 °C. All measurements were performed several times until reproducible results were obtained.

3. Gas sensing performance of a Ga_2O_3 based sensor

Gas sensing properties of commercial gallium oxide ($\beta\text{-Ga}_2\text{O}_3$, Sigma-Aldrich) coated sensor was studied at 530 °C towards different CO (8-125 ppm) concentrations in nitrogen atmosphere—oxygen free-conditions. Upon CO exposure the sensing performance of Ga_2O_3 was found to be similar to that of untreated-as-synthesized GaN (Figure s2).

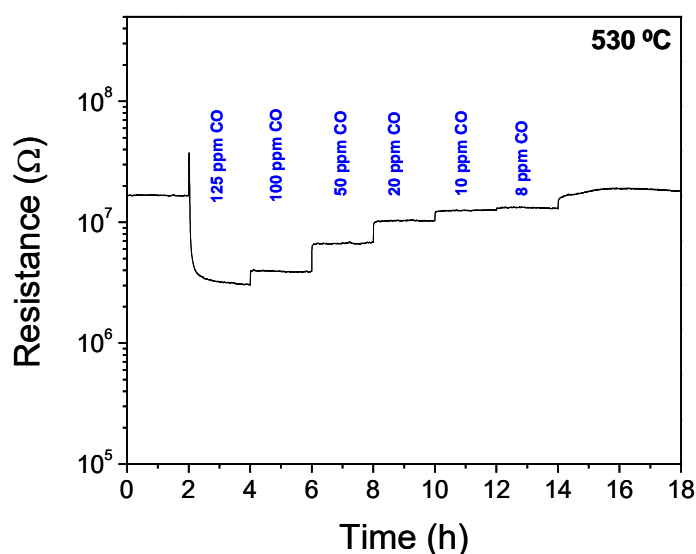


Figure s4. Transient response of commercial $\beta\text{-Ga}_2\text{O}_3$ sensors during exposure to CO (125, 100, 50, 20, 10 and 8 ppm) in nitrogen at 530 °C.

4. References

1. Kerlau, M.; Merdrignac-Conanec, O.; Reichel, P.; Barsan, N.; Weimar, U., Preparation and characterization of gallium (oxy)nitride powders - Preliminary investigation as new gas sensor materials. *Sensor Actuat B-Chem* **2006**, 115, (1), 4-11.