**Influence of ionic surfactant adsorption on the response of GaN/AlGaN/GaN pH sensors**

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**Introduction.**

Surfactants are of industrial interest for applications such as wetting, detergency and floatation. Moreover, ionic surfactants can adsorb on surfaces of the opposite charge, making them suitable for studying nanoscale interfacial charge properties. This work describes investigations into selective adsorption of cationic surfactant cetyltrimethylammonium bromide (CTAB) and anionic surfactant sodium dodecylsulphate (SDS) on GaN/AlGaN/GaN-based ion-sensitive field effect transistors (ISFETs) to provide insight into the pH-dependent surface charge of GaN, which is of interest in many applications requiring portable ion sensing.

**Methods.**

The nano-manufacturing of reference-electrode-free pH sensors based on GaN/AlGaN/GaN structures (Fig. 1a) was carried out using standard cleanroom techniques at Australian National Fabrication Facility – Western Australian Node. The major steps of the manufacturing included photolithography, mesa etching using Cl2-based reactive ion etching, metallisation, rapid thermal annealing, SU-8 passivation and packaging.

The manufactured pH sensors were tested without surface functionalisation. The sensors were excited by a 100 µA constant current source and immersed in various electrolytic solutions. The drain-source voltage across an open gate area in the sensor was measured as the sensor response. The solutions used in this work include HNO3 with or without SDS and NaOH with or without CTAB. The pH of the solutions was controlled manually by adding 1 M HNO3 or NaOH into the testing solutions, and for the combinations with a surfactant, the surfactant concentrations were kept constant, above twice the critical micelle concentrations (cmc). At those concentrations, the surfactants present in bulk solution as spherical micelles.

**Results and discussion.**

As shown in Fig. 1b, the results show that the sensor response is different in the presence of ionic surfactants, compared to the response to pH alone. Without the surfactants, conductivity decreases monotonically with an increasing pH as is typical for AlGaN/GaN-based pH sensors. In the presence of SDS, the scale of sensor conductivity change as a function of pH decreases significantly at low pH, reaching a near-plateau below pH 2.5. In the presence of CTAB, the trend of the sensor response vs. pH reverses above pH 10. As confirmed by separate AFM experiments studying the adsorption of ionic surfactants on GaN surfaces, this divergence of the sensor response is likely due to the GaN surface charge reversal caused by adsorbed surfactants.



**Fig. 1.** (a) Schematic of an ion sensor based on GaN/AlGaN/GaN heterostructure; (b) plot of the sensor conductance vs. pH under various conditions.

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