Surface states induced catalyst-free CO sensing at GaN and AlGaN/GaN heterostructures

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Abstract:

III-Nitride semiconductors owing unique material properties have proven their potential in the detection of light, chemical, biomolecules and toxic/explosive gases. Despite of numerous advantages *viz.* biocompatibility, high temperature/frequency tolerance and harsh/adverse environmental condition sustainability, the use of expensive catalysts (e.g. platinum) and higher operation temperature for gas sensing (>250^{o}C) has plagued the development of GaN based cost-effective sensor technology. Upto the best of our knowledge, literature lacks research articles on the development of catalyst-free CO sensors operating at room-temperature using GaN or AlGaN/GaN structures which indicates the necessity of dedicated scientific attention in this area. Therefore, we report the fabrication of nanoflowers-decorated GaN and AlGaN/GaN heterostructure based catalyst-free CO sensors operating at lower (including room) temperature. A set of planar as well as nanostructured GaN & AlGaN/GaN thin films were employed for sensors fabrication which exhibited significant CO sensing associated with its superior surface and interface properties. For in-depth understanding, the obtained results were thoroughly analyzed and correlated to investigate the underlying science/phenomenon which revealed that CO sensing on GaN (and AlGaN/GaN) is governed by the chemical nature of ambient-oxidation induced amorphous oxide (O_2^-, O^{2-} or OH^- species) layer grown on the surface. These surface state act as donor/acceptor states and perturbed the CO adsorption and charge transfer mechanism significantly. Besides, electron accumulation at AlGaN/GaN interface also influenced the critical parameters like schottky barrier height, ideality factor etc. which govern the effective carrier transport and ultimately the device performance. In conclusion, we have observed that the surface and interface states has a strong impact on the efficiency of GaN and AlGaN/GaN based fabricated CO sensors. However, being a first study of its kind, further research is required to explore to uncover the scientific phenomenon and optimization of device performance.

References:

1. M. Mishra, N. K. Bhalla, A. Dash and G. Gupta, Nanostructure GaN and AlGaN/GaN heterostructure for catalyst-free low-temperature CO sensing, Appl. Surf. Sci. 481, 379 (2019).