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Dennis Noll
Udo Schwalke
TU Darmstadt – ISTN, Schloßgartenstr. 8, 64289 Darmstadt, Germany

noll@iht.tu-darmstadt.de

Transfer-free fabrication of nanocrystalline graphene field-effect transistor gas sensor arrays

Gas sensor arrays for highly sensitive and selective detection of toxic gases have become a major topic in the recent years. Graphene, a two-dimensional material with high surface-to-volume ratio has shown to be a good candidate for that purpose [1]. Yet the successful fabrication of gas sensor arrays requires a scalable approach other than mechanical exfoliation.
In this contribution we demonstrate the transfer-free mass fabrication of hundreds of nanocrystalline graphene field-effect transistors (ncGFETs). Figure 1a shows the respective measured backgate input characteristics of 524 ncGFETs in ambient environment. Materials characterization using Raman spectroscopy, near-edge x-ray absorption fine structure and atomic force microscopy has confirmed the presence of a bi- to trilayer nanocrystalline graphene [2]. Characterization of the intrinsic gas sensing properties of the ncGFETs using a vacuum probing station have shown detection capabilities for toxic species including ammonia (NH_3), nitrogen dioxide (NO_2) and carbon monoxide (CO). The respective sensitivities under gaseous influence can be seen from backgate input characteristics of single ncGFETs as shown in figures 1b-1d. By the use of gas sensor arrays selectivity can be achieved by tuning the sensitivities of different ncGFETs by controlling the backgate bias. Moreover, from the hysteresis loop of the devices one can conclude on the gaseous species.

References

[1] Schedin F., Geim A.K., Morozov S.V., Hill E.W., Blake P., Katsnelson M.I., Novoselov K.S., Nat Mater, 9 (2007) 652-655
[2] Noll D., Hönicke P., Kayser Y., Wagner S., Beckhoff B., Schwalke U., ECS Journal of Solid State Science and Technology, 7 (2018) Q3108-Q3113

Figures

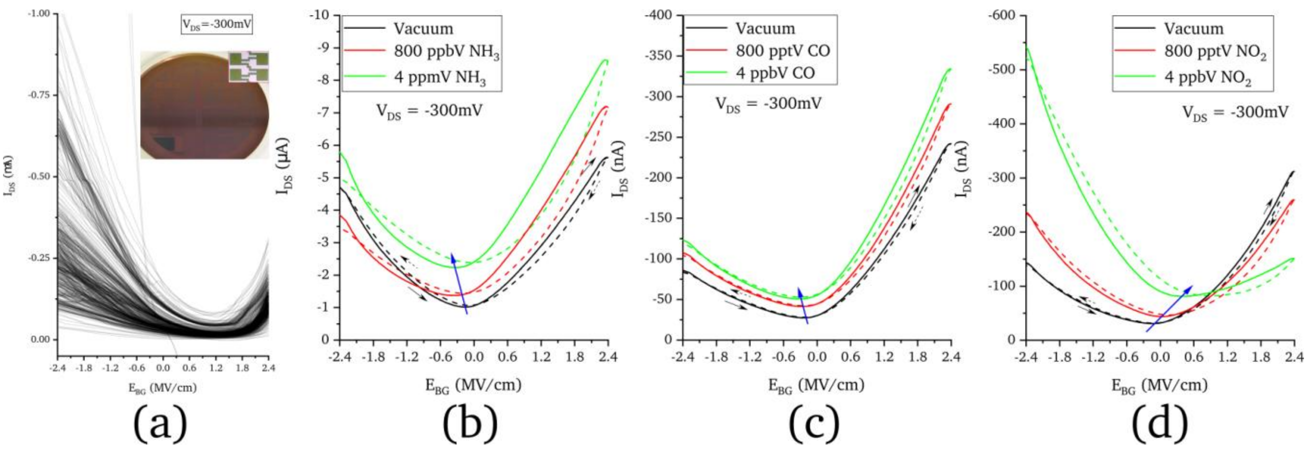

Figure 1: (a) Input characteristics of 524 ncGFETs measured in ambient air, inset shows 2" wafer with the respective devices. Input characteristics of different devices under influence of (b) NH_3 (5.0), (c) 1,000 ppm CO in dry technical air, (d) 1,000 ppm NO_2 in dry technical air. Concentrations have been calculated from the vacuum pressure in the chamber