Phototransistors from Liquid-Phase Exfoliated Transition Metal Monochalcogenide Flakes

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Abstract

LAYERED semiconductors of IIIA−VIA group, have attracted considerable attention in (opto)electronic applications thanks to their atomically thin structures and their (opto)electronic properties. Currently, two-dimensional (2D) indium selenide (InSe) and gallium selenide (GaSe) are emerging as promising candidates for the realization of thin-field effect transistors (FETs) and photodetectors due to their high intrinsic mobility (10^2 – 10^3 $cm^2V^{-1}s^{-1}$) [1] and their direct bandgap in an energy range (1.3 – 3.2 eV) suitable for UV, visible and NIR light detection [2,3]. A requirement for large-scale electronic applications is the development of low-cost, reliable industrial production processes. In this context, it has been recognized that liquid-phase exfoliation (LPE) of InSe and GaSe is a cost-effective and environmentally friendly way to formulate inks for FETs, presenting a significant advantage over conventional methods [4]. In this study, we present printed InSe and GaSe phototransistors that exhibit high responsivity (13 – 274 AW^{-1}) and fast response velocity (15 – 32 ms) [2,3]. Moreover, the GaSe phototransistors show an on-off current ratio of ~10^3 in the dark, which can be readily achieved without the need for complex design of drain/source contacts or gating techniques [2,3]. The gate-dependent photoresponse shows that the phototransistors can be modulated by the gate voltage. These results demonstrate that liquid-phase exfoliated InSe and GaSe are valid candidates for low-cost high-performance (opto)electronic devices.

REFERENCES

[1] Chen, J., Tan, X., Lin, P., Sa, B., Zhou, J., Zhang, Y., Wen, C. and Sun, Z., Physical Chemistry Chemical Physics, 2019, 21(39), pp.21898-21907.
[2] Curreli, N., Serri, M., Spirito, D., Lago, E., Petroni, E., Martín-García, B., Politano, A., Gürbulak, B., Duman, S., Krahne, R., Pellegrini, V. and Bonaccorso, F., Advanced Functional Materials, 2020, 30(13), p.1908427.
[3] Curreli, N., Serri, M., Zappia, M.I., Spirito, D., Bianca, G., Buha, J., Najafi, L., Sofer, Z., Krahne, R., Pellegrini, V. and Bonaccorso, F., Advanced Electronic Materials, (submitted)
[4] Bonaccorso, F., Bartolotta, A., Coleman, J.N. and Backes, C., Advanced Materials, 2016, 28(29), pp.6136-6166.

FIGURES

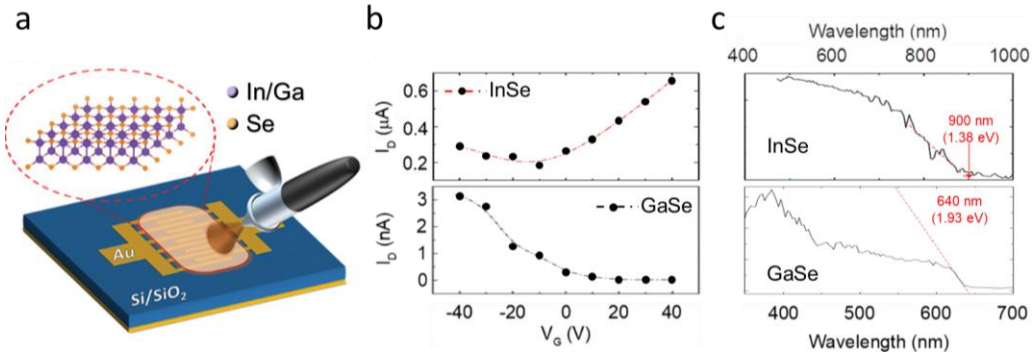

Figure 1: a) Schematic illustration of the InSe and GaSe phototransistors. b) Source–drain current (I_D) versus gate voltage (V_G) curve for InSe (top) and GaSe (bottom). c) Spectral responsivity of InSe (top) and GaSe (bottom) phototransistors