Sensing with Nanomaterials

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Drastically reduced dimensions and quantum confinement make nanomaterials excellent candidates for sensing applications. From chemical to light detection, quantum confinement in two-dimensional, one-dimensional and zero-dimensional materials yields exceptional sensitivity, with the underlying physics of the detection mechanisms being markedly different from that of devices based on bulk materials. I will briefly discuss examples of devices based on semiconducting two-dimensional transition metal dichalcogenides [1-3] and then focus on gapless graphene nanostructured into quantum dots. I will review our recent studies of these graphene quantum dots as very sensitive detectors of light [4-6], as well as sensitive detectors of magnetic switching of molecular magnets [7], opening the way to in-situ characterization and electrical read-out of the magnetic state of these molecules for future applications in high density memory and quantum computing.

References:

[1] Han, P.; St Marie, L.; Wang, Q. X.; Quirk, N.; El Fatimy, A.; Ishigami, M.; Barbara, P. Highly sensitive MoS2 photodetectors with graphene contacts. Nanotechnology 2018, 29 (20). DOI: 10.1088/1361-6528/aab4bb.

[2] Han, P.; Adler, E. R.; Liu, Y. J.; St Marie, L.; El Fatimy, A.; Melis, S.; Van Keuren, E.; Barbara, P. Ambient effects on photogating in MoS2 photodetectors. Nanotechnology 2019, 30 (28), 6, Article. DOI: 10.1088/1361-6528/ab149e.

[3] Adler, E.; Le, T.; Boulares, I.; Boyd, R.; He, Y.; Rhodes, D.; Van Keuren, E.; Barbara, P.; Najmaei, S. Observation of Multi-Phonon Emission in Monolayer WS₂ on Various Substrates. NANOMATERIALS 2024, 14. DOI: 10.3390/nano14010037.

[4] El Fatimy, A.; Myers-Ward, R. L.; Boyd, A. K.; Daniels, K. M.; Gaskill, D. K.; Barbara, P. Epitaxial graphene quantum dots for high-performance terahertz bolometers. Nature Nanotechnology 2016, 11 (4), 335-+. DOI: 10.1038/nnano.2015.303.

[5] El Fatimy, A.; Nath, A.; Kong, B. D.; Boyd, A. K.; Myers-Ward, R. L.; Daniels, K. M.; Jadidi, M. M.; Murphy, T. E.; Gaskill, D. K.; Barbara, P. Ultra-broadband photodetectors based on epitaxial graphene quantum dots. Nanophotonics 2018, 7 (4), 735-740. DOI: 10.1515/nanoph-2017-0100.

[6] El Fatimy, A.; Han, P. Z.; Quirk, N.; St Marie, L.; Dejarld, M. T.; Myers-Ward, R. L.; Daniels, K.; Pavunny, S.; Gaskill, D. K.; Aytac, Y.; et al. Effect of defect-induced cooling on graphene hot-electron bolometers. Carbon 2019, 154, 497-502, Article. DOI: 10.1016/j.carbon.2019.08.019.

[7] Alqahtani, A.; Henry, D.; Havlicek, L.; Marie, L. S.; Hruby, J.; Sojka, A.; Hale, M.; Felsenfeld, S.; Fatimy, A. E.; Myers-Ward, R. L.; et al. Electrical Detection of Magnetization Switching in Single-Molecule Magnets. Arxiv 2024, preprint. DOI: arXiv:2407.21156.