Holistic Development of Graphene & Carbon Nanotube-based Electronics: From Growth to Devices

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Nanomaterials present unprecedented potential in the reimagining of incumbent electronics devices and the production of entirely new and functionally unique technologies. This talk will focus on the growth, integration and deployment of nanomaterials, with a focus on their integration into ubiquitous electron emission technologies. Found in travelling wave tubes, electron beam lithography systems, microwave amplifiers, thin film displays, advanced lighting units, and X-ray sources; the field of nano-vacuum electronics is returning to the fore in a nano-driven renaissance. Graphitic nano-carbons out-perform conventional metallic Spindt-like electron emitters across virtually all standardised metrics. Carbon nanotubes (CNT) and graphene offer high-aspect ratios, chemical inertness, near instantaneous temporal response, with low sputter cross-sections; all of which contribute to their use as a unique platform for enhanced electron emitters. Their low turn-on fields, negligible hysteresis, and high temporal stability have resulted in significant strides towards new electron emission platforms and devices. Nevertheless, the efficient use of these emerging nanomaterials in various electron emission applications has yet to gain any significant commercial traction, largely due to temporal instabilities and challenges associated with yield and device-to-device reproducibility. Indeed, the devices that have successfully achieved high technology-readiness levels are based on poorly functioning, coarsely deposited, post-growth techniques with little to no spatial registration or controlled material alignment, using techniques often based on simplistic and material-damaging wet chemistry. Enhanced functionality, including resistance toward electromigration and beam shaping, requires the ability to define, with high fidelity and reproducibility, sub-micron-scale periodic features. Here I will present our continuing, and largely pragmatic work on the development of nano-carbon based electron guns including details on the growth, characterisation and integration of chemical vapour deposited carbon nanotubes and graphene towards realising nanoscale fin electron sources, low-cost electron emitters on catalytically activated metal mesh, silicon-on-insulator ballasted CNT arrays, high electron transparent graphene triodes, and the first large-area graphene-based electron emission display.

References

[1] M. T. Cole, T. Hallam, W. I. Milne, G. S. Duesberg, Small 2013.
[2] M. T. Cole, C. Li, W. Lei, K. Qu, K. Ying, Y. Zhang, A. R. Robertson, J. H. Warner, S. Ding, X. Zhang, B. Wang, W. I. Milne, Adv. Funct. Mater. 2013.

Figures

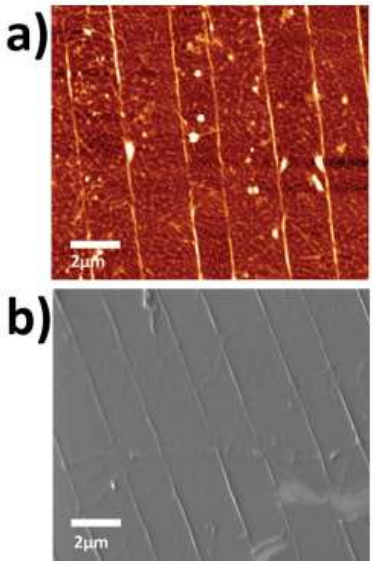

Figure 1: Graphene fin electron source.

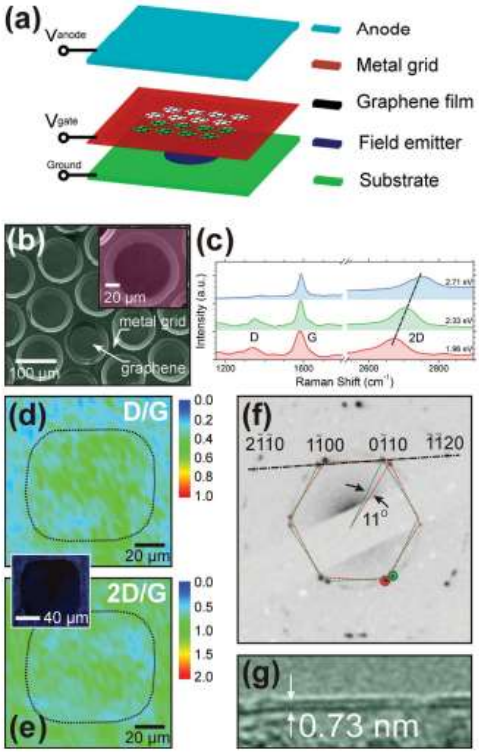

Figure 2: Graphene-based triode gate.