Observing diffusion of charge and heat in monolayer films of 9-armchair graphene nanoribbons

L. Moczko[1]
S. Varghese[1,2], J. D. Mehew[2], H. I. Wang[3,4], A. Narita[3,5], A. W. Cummings[2], K. J. Tielrooij[1,2]

[1] *Department of Applied Physics, TU Eindhoven, Eindhoven, The Netherlands.*
[2] *Catalan Institute of Nanoscience and Nanotechnology (ICN2), BIST and CSIC, Barcelona, Spain*
[3] *Max Planck Max Planck Institute for Polymer Research, Mainz, Germany*
[4] *Debye Institute for Nanomaterials Science, Utrecht University, Utrecht, The Netherlands*
[5] *Organic and Carbon Nanomaterials Unit, Okinawa Institute of Science and Technology Graduate University, Okinawa, Japan*
l.moczko@tue.nl

Graphene nanoribbons (GNRs) are a family of one-dimensional materials formed by strips of graphene. They inherit the outstanding electronic properties of two-dimensional graphene while benefiting from additional spatial confinement, which can open a bandgap or generate topological edge states. As such, the properties of GNRs depend strongly on their width and edge geometry, two parameters that can be precisely tuned during the fabrication process [1]. Here, we focus on monolayer films of 9-armchair 9a-GNRs made by chemical vapor deposition (CVD), a scalable bottom-up growth technique that generates arrays of short nanoribbons (< 20 nm) aligned in packed domains with a typical size of a few tens of nm [2, 3].

Properly understanding the transport of electrons, excitons and heat in such films of 9a-GNRs is necessary before envisioning their use for any application. Our approach is to directly follow in space and time the diffusion processes at play in a contact-free way using pump-probe spatiotemporal microscopy [4, 5] coupled to quantum transport calculations [6]. We show that short-lived (< 1 ps) photoexcited quasi-free carriers present a diffusivity of almost 200 cm^2s^{-1}, corresponding to a charge mobility up to 550 $cm^2V^{-1}s^{-1}$, before forming excitons that spread with a diffusivity of a few tens of cm^2s^{-1} [7]. These values are comparable to the electron mobility in CVD-grown graphene and the diffusivity of excitons in monolayer TMDs. On longer timescales (> 100 ps), the diffusion is dominated by phononic heat and our first results suggest a heat diffusivity between 0.2 and 1.0 cm^2s^{-1}.

References

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