Synthesis and single-photon emission properties of graphene quantum dots

Julien Lavie, Zhao Shen, L. Orcin-Chaix, L. Rondin, C. Diederichs, P. Roussignol, Y. Chassagneux, C. Voisin, K. Müllen, A. Narita, et al.

SYNTHESIS AND SINGLE PHOTON EMISSION PROPERTIES OF GRAPHENE QUANTUM DOTS

J. Lavie,[1] S. Zhao,[2] L. Orcin-Chaix,[1,2] L. Rondin,[2] C. Diederichs,[3] Ph. Roussignol,[3] Y. Chassagneux,[3] C. Voisin,[3] K. Müllen,[4] A. Narita,[4] J.-S. Lauret[2] and S. Campidelli[1]

[1]LICSEN, NIMBE, CEA, CNRS, Université Paris-Saclay, FRANCE
[2]Laboratoire Aimé Cotton, CNRS, Univ. Paris-Sud, ENS Cachan, Université Paris Saclay - bat 505, campus d'Orsay, 91405 Orsay cedex France
[3]Laboratoire Pierre Aigrain, Ecole Normale Supérieure, CNRS, Université Pierre et Marie Curie, Université Paris Diderot, PSL, Sorbonne Paris Cité, Sorbonne Université, 24, rue Lhomond, 75005 Paris, FRANCE
[4]Max Planck Institute for Polymer Research, Ackermannweg 10, 55128 Mainz, GERMANY

The outstanding electronic, optical and mechanical properties of graphene strongly inspire the scientific community at both the fundamental and applicative levels. However, along this way several key scientific issues have to be addressed and one of the main challenges of the field is the control and modification of graphene electronic properties, and notably the controlled opening of a sizable bandgap. For the last decade, a great attention has been paid to the size reduction of graphene using conventional top-down approaches (lithography and etching, thermal treatments and oxidation of bulk materials) to fabricate graphene quantum dots (GQDs)[1] or graphene nanoribbons (GNRs).[2] However, top-down approaches do not permit to manipulate the structure of the material at the atomic scale. In particular, they do not allow a sufficient control of the morphology and oxidation state of the edges, which drastically impact the properties. In order to truly control, with the required level of precision, the morphology and the composition of the materials and of its edges, the bottom-up approach is the relevant way to proceed[3][4].

With the aim to study and understand the optical properties of GQD materials, we performed the bottom-up synthesis of different families of nanoparticles exhibiting controlled shapes and edges. Using absorption, steady-state and time-resolved photoluminescence and photoluminescence excitation (PLE) spectroscopy, we try to establish the intrinsic optical properties of the GQDs and understand how the structure influences the properties. Here we present the synthesis of a new series of rod-shaped graphene nanoparticles (GNRods); we also present the single photon emission properties of a triangle-shaped GQD (Figure 1).[5]

References

[1] M. Bacon, S.J. Bradley, T. Nann *Part. Part. Syst. Charact.* 31 (2014), pp. 415-428.
[2] M. Terrones, A.R. Botello-Méndez, J. Campos-Delgado, F. Lopez-Urias, Y.I. Vega-Cantu, F.J. Rodriguez-Marcias, A L. Elias, E. Munoz-Sandoval, A.G. Cano-Marquez, J.C. Charlier, H. Terrones, *Nano Today* 5 (2010), pp. 351-372.
[3] J. Wu, W. Pisula, K. Müllen, *Chem. Rev.* 107 (2007), pp. 718-747.
[4] A. Narita, X.Y. Wang, X. Feng, K. Müllen *Chem. Soc. Rev.* 44 (2015), pp. 6616-6643
[5] S. Zhao, J. Lavie, L. Rondin, L. Orcin-Chaix, C. Diederichs, P. Roussignol, Y. Chassagneux, C. Voisin, K. Müllen, A. Narita, S. Campidelli, and J.S. Lauret, *Nat. Commun.*, (2018) 9:3470.

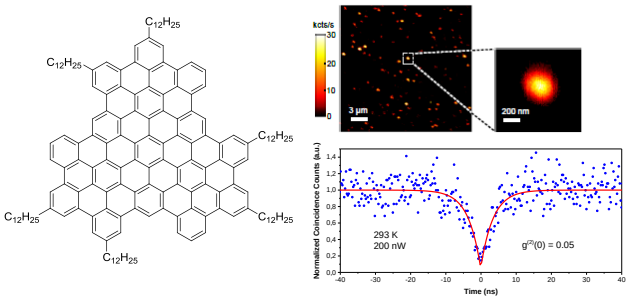

Figure 1: Structure of the triangular-shaped GQD, photoluminescence map of the GQD dispersed in matrix and second-order correlation function $g^{(2)}(\tau)$ recorded for the QGD.

corresponding author: stephane.campidelli@cea.fr