

Mid- and high-temperature exciton photophysics of carbon nanotubes and their applications

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Optical properties of single-walled carbon nanotubes (SWNTs), dominated by correlated electron-hole bound states known as excitons [1-3], have been intensively studied for exploring fundamental photophysics in nearly ideal quasi-one-dimensional systems and their applications in the fields ranging from optoelectronics to bioimaging. Because of the strong Coulomb interaction resulting from 1D quantum confinement and weak dielectric screening, excitons in semiconducting SWNTs have binding energies on the order of 0.5 eV. Thus, SWNTs have offered a unique system for the study of excitons and their applications at high temperatures even much more than room temperature. Here we discuss our recent studies on exciton photophysics in SWNTs and their applications at mid- and high-temperatures. These include intrinsic high-temperature radiation properties of individual structure-defined semiconducting and metallic SWNTs at more than 1000 K [4], and applications of efficient phonon-assisted up-conversion luminescence phenomena [5,6] of SWNTs around living body temperatures for probing distribution of individual SWNTs trapped in mice liver tissues [7], autofluorescence-free real-time anatomical imaging of mice using a silicon-based image sensor, and for deep-tissue luminescence thermometric imaging toward realization of non-contact in vivo local temperature measurement for biomedical applications [8].

- [1] T. Ando, *J. Phys. Soc. Jpn.* 66, 1066 (1997).
- [2] F. Wang, G. Dukovic, L. E. Brus, and T. F. Heinz, *Science* 308, 838 (2005).
- [3] J. Maultzsch, R. Pomraenke, S. Reich, E. Chang, D. Prezzi, A. Ruini, E. Molinari, M. S. Strano, C. Thomsen, and C. Lienau, *Phys. Rev. B* 72, 241402(R) (2005).
- [4] T. Nishihara, A. Takakura, Y. Miyauchi, and K. Itami, submitted.
- [5] N. Akizuki, S. Aota, S. Mouri, K. Matsuda, and Y. Miyauchi, *Nat. Commun.* 6, 8920 (2015).
- [6] S. Aota, N. Akizuki, S. Mouri, K. Matsuda, and Y. Miyauchi, *Appl. Phys. Express* 9, 045103 (2016).
- [7] S. Okudaira, Y. Iizumi, M. Yudasaka, T. Okazaki, K. Matsuda, and Y. Miyauchi, the 51st Fullerenes-Nanotubes-Graphene General Symposium, September 7-9, 2016, Hokkaido, Japan.
- [8] K. Hachiya, S. Okudaira, Y. Konno, Y. Maeda, K. Matsuda, and Y. Miyauchi, the 54th Fullerenes-Nanotubes-Graphene General Symposium, March 10-12, 2018, Tokyo, Japan.