Novel excitonic properties of nano-carbon and atomically thin layered materials

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Recently, nano-carbon and atomically thin layered materials such as carbon nanotube, and graphene have attracted a great deal of attention from viewpoint of fundamental physics and optical device application. The single-walled carbon nanotubes with only about 1-nm diameter have novel electronic properties, because of their degenerated band structures and enhanced Coulomb interaction with a 1-dimensional (1D) cylindrical structure. The enhanced Coulomb interaction in carbon nanotubes leads to the formation of stable excitons with extremely large binding energies of about 400 meV. It is anticipated that the excitons and carriers in carbon nanotubes show various interesting physical aspects such as mesoscopic quantum phenomena, and device applications [1-6].

The novel excitonic properties of carbon nanotubes were investigated by advanced laser spectroscopic techniques. We studied the excitonic properties of carrier-doped carbon nanotubes [2-4] and found the positive and negative charged excitons (trions) at room temperature in the carbon nanotubes [2,4]. This is the first observation of room temperature stable trion (charged exciton) among various semiconductors, which will open the door to realize the spin manipulation in carbon based materials. Recently, we successfully improved the photoluminescence quantum efficiency of nanotubes using 0D-1D hybrid nanostructure [5]. Moreover, the novel optical properties of atomically thin layered materials such as transition metal dichalcogenides will be discussed [7].

[1] R. Matsunaga, K. Matsuda, *et al.*, *Phys. Rev. Lett.* **101,** 147404 (2008).

[2] R. Matsunaga, K. Matsuda, *et al.*, *Phys. Rev. Lett.* **106,** 037404 (2011):*Physics Viewpoint*; *Physics* **4,** 5 (2011).

[3] S. Konabe, K. Matsuda, *et al.*, *Phys. Rev. Lett.* **109,** 187403 (2012).

[4] J. S. Park, N. Nakashima, K. Matsuda, *et al, J. Am. Chem. Soc.* **134,** 14461 (2012).

[5] Y. Miyauchi, K. Matsuda, *et al.*, *Nature Photonics* **7,** 715 (2013).

[6] F. Wang, K. Matsuda, *et al.*, *Nature Commun.* **6,** 6305 (2015).

[7] D. Kozawa, K. Matsuda, G. Eda, *et al.*, *Nature Commun.* **5,** 4543 (2014).