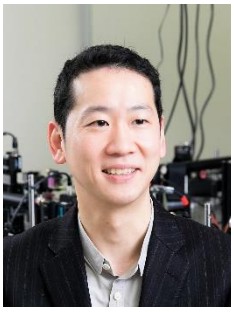
Nanoscale Quantum Photonics Laboratory (2023)
Chief Scientist: Yuichiro Kato (Ph.D.)



(0) Research fields

CPR Subcommittee**:** Engineering
Keywords: condensed matter physics, nanoscale device physics, carbon nanotubes, photonic crystals, microspectroscopy

(1) Long-term goal of laboratory and research background

Quantum technologies are expected to make important developments in various fields of engineering including computing, sensing, metrology, and communication. Since quantum effects become more evident and more robust as the system scales down, devices with atomically precise elements could provide a route for quantum technologies operating at elevated temperatures. Our research focuses on the optical properties of nanomaterials and the physics of nanoscale photonic devices, investigating new approaches for utilizing their quantum properties. By engineering atomically defined nanostructures and integrating them into nanoscale devices, we explore novel concepts in photonics for future quantum technologies.

(2) Current research activities (FY2023) and plan

Resonant exciton transfer in mixed-dimensional heterostructures for overcoming dimensional restrictions in optical processes

N. Fang, Y. R. Chang, D. Yamashita, S. Fujii, M. Maruyama, Y. Gao, C. F. Fong, K. Otsuka, K. Nagashio, S. Okada, Y. K. Kato, *Nature Commun.* **14**, 8152 (2023).

We have investigated the exciton transfer process in carbon nanotube (CNT)/tungsten diselenide (WSe_2) mixed-dimensional heterostructures. Compared with conventional direct excitation of CNTs, the WSe_2-based excitation offers an immensely larger absorption area, broader spectral response, and polarization-independent efficiency, all of which stem from the 2D nature of the material. Following an extensive exploration of CNT chirality and WSe2 layer number combinations, we observe that the exciton transfer efficiency can be significantly modulated due to band alignment. The transfer process shows a resonant behavior, leading to a pronounced enhancement in excitation with fast transfer from the WSe_2 exciton states. Employing this unique excitation process, we demonstrate simultaneous bright emission from an array of CNTs with varied chiralities and orientations.

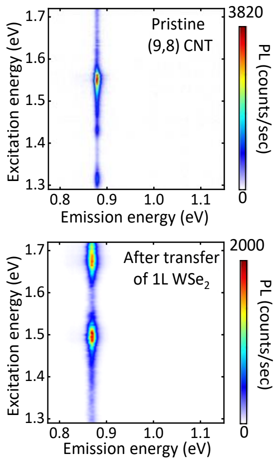


Fig. 1: Photoluminescence excitation maps before and after the formation of the heterostructure.

(3) Members

(Chief Scientist)
Yuichiro Kato
(Research scientist)
Wataru Terashima
(Special Postdoctoral Researcher)
Chee Fai Fong
(Postdoctoral Researcher)
Mengyue Wang
Hiroyuki Nishidome
Ufuk Erkilic
Clement Deleau
(Visiting Researcher)
Yih-Ren Chang
(Visiting Scientist)
Keigo Otsuka
(Assistant)
Yoriko Nissaka

(4) Representative research achievements

1. N. Fang, Y. R. Chang, D. Yamashita, S. Fujii, M. Maruyama, Y. Gao, C. F. Fong, K. Otsuka, K. Nagashio, S. Okada, Y. K. Kato, "Resonant exciton transfer in mixed-dimensional heterostructures for overcoming dimensional restrictions in optical processes," Nature Commun. **14**, 8152 (2023).

Group Photo

Group Webpage

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