

# Arakawa-Iwamoto LAB.

## [Quantum dots and advanced nano-photonics]

Center for Photonics Electronics Convergence, Institute of Industrial Science  
Institute for Nano Quantum Information Electronics

<http://qdot.iis.u-tokyo.ac.jp>

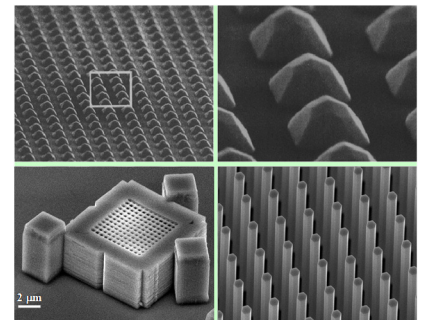
### Quantum Nano Devices, Nano Optoelectronics

Department of Electrical Engineering and Information Systems, Department of Advanced Interdisciplinary Studies, Graduate School of Engineering  
Department of Physics, Graduate School of Science

Since the first proposal of the quantum box (quantum dot) by Arakawa and Sakaki in 1982, we have been investigating quantum nanostructures and devices for future telecommunications applications. Our major subjects include: fabrication of semiconductor nanostructures such as quantum dots and photonic crystals, study of novel physics in such nanostructures, and development of nano-photonics and quantum information devices. We are also studying devices for green electronics, such as solar cells. Currently, we are undertaking a large national project, "Center of Excellence for Nano Quantum Information Electronics" by MEXT, which is aiming for realizing the future information society by developing novel devices based on quantum physics (FY2006-2015, a total of about JPY 6.2 billion). In addition, we are leading basic research on future LSI-photonics convergence technologies in the framework of Future Pioneering Program by METI (FY2012-2021, a total of about JPY 30 billion). We also belong to Center for Photonics Electronics Convergence established in IIS.

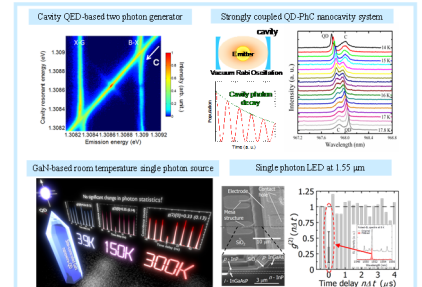
#### Fabrication of Nanostructures: Quantum Dots and Photonic Crystals

In order to create nanosystems which enable us to manipulate individual electrons or photons, we have been developing fabrication technologies for nanostructures such as quantum dots (QDs) or photonic crystals (PhCs) by employing metalorganic chemical vapor deposition, molecular beam epitaxy, or electron beam lithography. So far, we have demonstrated state-of-the-art InAs/GaAs or III-nitride QDs and nanowires for telecom and quantum information applications. In addition, we have developed fabrication technologies for 3D PhCs, leading to the world's highest Q factor in a 3D PhC nanocavity, together with lasing therein and coupling to single QDs. We also succeeded in assembling 3D chiral PhC nanostructures for manipulating the spin angular momentum of photons.



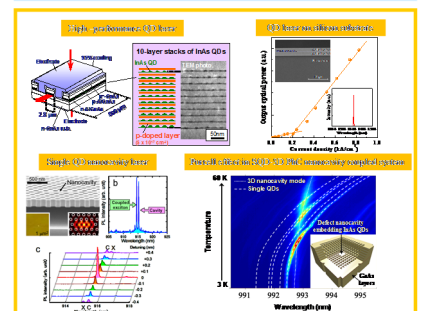
#### Optical Properties of Nanostructures and Basic Research on Quantum Information Devices

We have been studying electronic/optical properties of QDs, PhCs and their combined structures using various specially-tailored experimental techniques. In particular, our optical microscopes can access nanoscale individual QDs and their single photon emission, giving a technological foundation for exploring the cutting-edge nano/quantum world. Currently, we have demonstrated single photon emission from QD-in-nanowires, ultrafast coherent control of QD excitons, strong coupling in coupled QD-photonic crystal nanocavity systems, and so on. In addition, we have been strongly promoting basic research on quantum information devices, and so far demonstrated single photon LEDs and III-nitride-based room temperature single photon generators. Moreover, we have realized secure quantum key distribution over 100 km distance by developing high-performance single photon sources at 1.55 μm telecom-band and an efficient quantum key distribution system.



#### Development of Nano Optoelectronic Devices and LSI-Photonics Convergence Technologies

Our research is directed toward advanced nano-photonics devices incorporating QDs or PhCs. In particular, by working in close collaboration with industry, we have developed high-quality QD lasers as well as QD-based green lasers. Also, high-quality PhC nanocavity-based single QD lasers and single QD-3D PhC nanocavity coupled system have been successfully realized. In addition, next-generation photonics-electronics convergence system technologies featuring high-efficiency light sources on silicon substrates are also under development. Among them, we have realized telecom-band 1.3 μm QD lasers on silicon substrates by employing wafer bonding techniques.



#### Green Electronics and Photonics

For the purpose of realizing a green information society, we are focusing on research and development of high-efficiency energy conversion devices and flexible electronics devices. Especially, fabrication technologies for high-performance QD solar cells have been developed by using sophisticated crystal growth techniques, and the possibility of ultrahigh efficiency (75 %) multilevel intermediate band solar cells has been theoretically predicted. Also, we develop fabrication technologies of organic transistors for flexible electronics applications. Outstanding results have been achieved, including low-voltage-operating / high-speed organic CMOS circuits.

