Arakawa-Iwamoto LAB.

［Quantum dots and advanced nano-photonics］

Institute of Industrial Science & Institute for Nano Quantum Information Electronics

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

Quantum Nano Devices, Nano Optoelectronics

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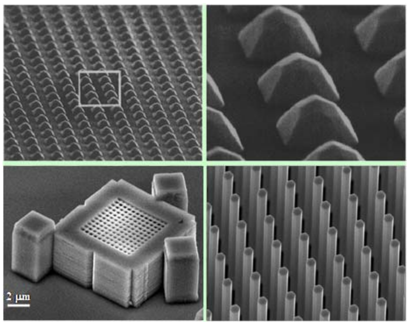
Since the first proposal of the quantum box (quantum dot) by Arakawa and Sakaki in 1982, we have investigated quantum nanostructures and devices for future telecommunications applications. Our major subjects include: development of semiconductor nanostructures such as quantum dots and photonic crystals, study of novel physics in nanostructures, and development of nano-photonic and quantum information devices. We are also studying fundamental devices for green electronics, such as solar cells and organic semiconductor devices. Currently, we are undertaking a large national project, “Center of Excellence for Nano Quantum Information Electronics,” which is aiming for realizing the future information society by developing novel devices based on quantum physics (2006-2015, a total of about JPY 6.2 billion). Also, we are pioneering basic research on future LSI-photonics fusion technologies in the framework of Funding Program for World-Leading Innovative R&D on Science and Technology (2009-2013, a total of about JPY 4.5 billion).

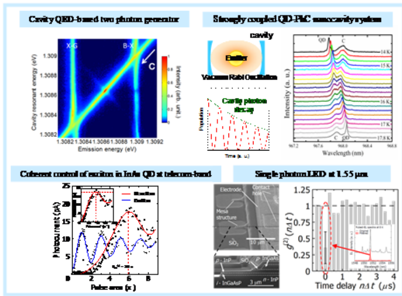
Fabrication of Nanostructures: Quantum Dots and Photonic Crystals

In order to create nanosystems which enable us to manipulate individual electrons or photons, we develop 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. We have succeeded in fabricating state-of-the-art InAs/GaAs QDs and nanowires for telecommunications and quantum information device applications, as well as III-nitride QDs and nanowires. In addition, we also develop fabrication technologies for 3D PhCs. The world’s highest Q factor (~ 38,500) in a 3D PhC nanocavity and lasing from the cavity have been achieved. We have also realized single QD-3D PhC nanocavity coupled system.



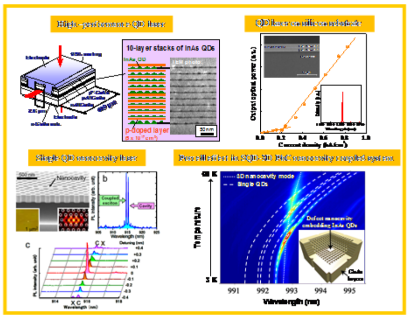
Studies on Optoelectronic Properties of Nanostructures, Basic Research on Quantum Information Devices

Electronic/optical properties of QDs or PhCs are experimentally investigated by using sophisticated spectroscopic techniques including a single QD spectroscopy system we developed in-house, which produces world-leading achievements continuously. In this regard, we have successfully observed the relaxation of coupled quantum states. The physics in a coupled QD-photonic crystal nanocavity system has also been studied. In addition, we promote basic research on quantum information devices. We have realized high-performance single photon sources operating at 1.55 μm telecom band, established a quantum key distribution system, and demonstrated secure key distribution over 50 km distance. In addition, a number of results have also been achieved; i.e., single photon LEDs, single photon generation at 200 K from III-nitride QDs, and realization of coherent control of QD excitons.



Development of Nano Optoelectronic Devices and LSI-Photonics Fusion Technologies

Our research is directed toward advanced nano-photonic 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.