【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Engineering)

Title of Project : Solid-state Quantum Electrodynamics in Quantum Dot-Nanocavity Multiply-Coupled Quantum Systems and Its Application to Novel Light Sources

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Research Project Number : 15H05700 Researcher Number : 30134638
Research Area : Quantum Nanodevice Engineering
Keyword : Quantum Dots, Photonic Crystals, Cavity Quantum Electrodynamics, Semiconductor Lasers

【Purpose and Background of the Research】

The physics of light matter interaction is of intense scientific interest and provides a strong basis for advancing diverse optoelectronic devices. In particular, cavity quantum electrodynamics (CQED), in which the interaction between cavity photons and quantum emitters is treated, has played an essential role in the development of quantum optics as well as state-of-the-art lasers.

In this project, we will explore the frontiers of solid-state CQED using quantum dots (QD) coupled to photonic crystal nanocavities realized on tiny semiconductor chips. We will primarily investigate CQED physics in QD-nanocavity multiply-coupled quantum systems via developing the technological foundations required for the tailored fabrication of such systems. We will further conduct fundamental research to carry forward scientific progress to the development of novel light sources including few-QD nanolasers.

【Research Methods】

We will intensively elaborate the fabrication technologies for improving QD-CQED systems and build up a basis for fabricating multiply-coupled QD-nanocavity systems. These efforts will open an avenue for pursuing advanced solid-state CQED, including single-photon-level nonlinear optical phenomena as well as cooperative effects in multiple quanta systems. We will also seek novel functionalities in multiply-coupled CQED systems using modern theoretical methods rooted in statistics. Further effort will be spent into developing next-generation QD light sources. We will endeavor to attain control over some of the physical processes in QD-based systems for boosting light source performance. We will also work on functional QD light sources that take advantage of high integratability, quantum spin, and the possibility of high temperature and current-driven operation of QD-CQED systems.

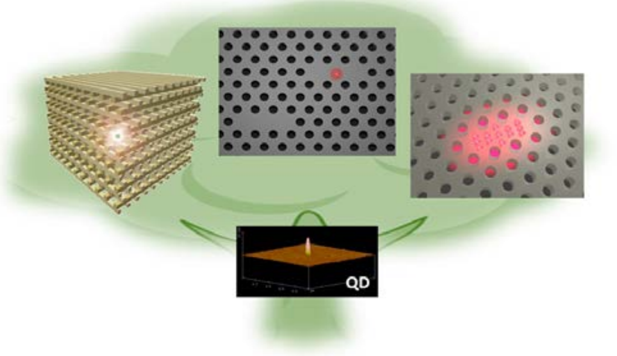

Fig.1 Conceptual schematic of the QD-CQED systems targeted in this project.

【Expected Research Achievements and Scientific Significance】

We believe that our research here will lay the groundwork for accessing diverse physics in high quality QD-CQED systems as well as in multiply-coupled quantum systems. These activities could have a lasting impact on the entire CQED research field. In addition to the influence on basic science, the advances into QD-based light sources that will be made here will open a new field of semiconductor light sources, potentially playing key roles in the forthcoming data-driven society, where ultra-compact low-energy-consumption light sources would be required for widely spread cyber physical systems.

【Publications Relevant to the Project】

- M. Nomura, N. Kumagai, S. Iwamoto, Y. Ota, and Y. Arakawa: Laser oscillation in a strongly coupled single quantum dot nanocavity system, Nat. Phys., **6**, 279–283 (2010).
- Y. Arakawa, S. Iwamoto, M. Nomura, A. Tandaechanurat and Y. Ota: Cavity Quantum Electrodynamics and Lasing Oscillation in Single Quantum Dot-Photonic Crystal Nanocavity Coupled Systems, *IEEE J. Sel. Top. Quantum Electron.*, **18**, 1818–1829 (2012).

【Term of Project】 FY2015-2019

【Budget Allocation】 399,500 Thousand Yen

【Homepage Address and Other Contact Information】

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