【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Engineering)

Title of Project : Photoelectric conversion system of spin-information utilizing semiconductor quantum dots

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Research Project Number : 16H06359 Researcher Number : 00333906
Research Area : Electronic materials/Electric materials
Keyword : Electronic materials (semiconductor, magnetic), Quantum structure, Fabrication method

【Purpose and Background of the Research】

Electrical injection of spin-polarized electrons from ferromagnetic metallic electrodes into III-V compound semiconductor quantum dots (QDs) will be studied, where QDs are used to fabricate optical active layers for photoelectric conversion of spin information. In QDs, electron-spin states can be conserved during an emission process, enabling us to transform spin information into circular polarization of light and vice versa.

We study spin-polarized light emitting diodes based on QDs by investigating ultrafast spin injection into the QDs and spin transport in semiconductor barriers. Optical resonators for efficient photoelectric conversion are fabricated along with circularly polarized stimulated emitters and spin-polarized photo-diodes using QDs.

The above research is aimed at establishing a technology base for photoelectric conversion of spin-information utilizing QDs [Fig. 1].

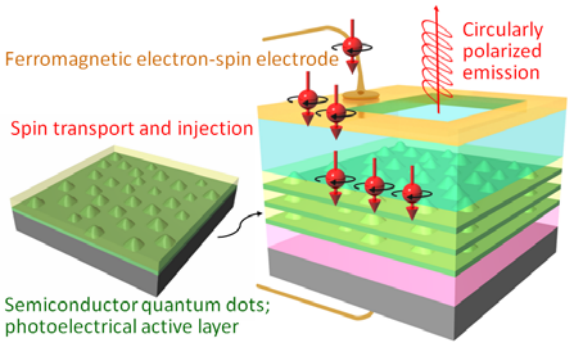

Figure 1 A schematic of photoelectric spin-conversion device utilizing QD active layers

【Research Methods】

We fabricate coupled QD structures with two-dimensional (2D) electron systems of quantum wells (QWs) and achieve efficient spin capture as well as ultrafast spin injection [Fig. 2]. Spin transport in semiconductor barriers is also studied. Quantum structures for room-temperature operation can be designed based on the temperature dependences of spin states and the relaxation in spin injection. Nanoscale optical resonators suitable for efficient photoelectric spin conversion are fabricated along with investigating the basic properties of circularly polarized stimulated emitters and spin-polarized photo-diodes using QD active layers.

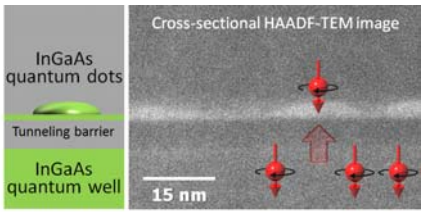

Figure 2 A QD structure coupled with a QW

【Expected Research Achievements and Scientific Significance】

Spin-polarized wavefunctions and the dynamics in QDs coupled with 2D electron systems, and subsequent energy relaxation are essential for spin injection into QDs, which will be an important achievement in material science. Photoelectric spin conversion at room temperature will facilitate future applications of semiconductor spintronics, which stays in a basic state of research to date.

【Publications Relevant to the Project】

・X.-j. Yang et al., "Ultrafast spin tunneling and injection in coupled nanostructures of InGaAs quantum dots and quantum well",
Applied Physics Letters **104**, 01240:1-4, 2014.
・T. Yamamura et al., "Growth-temperature dependence of optical spin-injection dynamics in self-assembled InGaAs quantum dots",
Journal of Applied Physics **116**, 094309:1-7, 2014.

【Term of Project】 FY2016-2020

【Budget Allocation】 142,500 Thousand Yen

【Homepage Address and Other Contact Information】

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