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

Science and Engineering (Interdisciplinary Science and Engineering)

Title of Project : Development and application of valley-spin photonics in atomically thin layered materials

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Research Project Number : 16H06331 Researcher Number : 40311435
Research Area : Applied physics
Keyword : Optical properties, Nanoscale control physics

【Purpose and Background of the Research】

Since the realization of atomically thin layered materials, the studies of these materials cause the paradigm-shift in material and optical sciences. There is a coupling between valley in the momentum space and spin degree of freedom in the atomically thin materials, called as valley-spin. This valley spin would open the frontier of research fields, which is different from charge and spin in the conventional electronics and photonics.

In this project, we will study the novel quantum optical phenomena related to the valley-spin and its coherent control by state of art optical spectroscopy in the transition metal dichalcogenides, and metal-monochalcogenides (Fig. 1). We would like to develop the new research field of valley-spin photonics for optical and material science research fields.

【Research Methods】

We will develop the element technology for generation, detection, and control of valley-spin in the atomically thin layered materials toward the valley-spin photonics. In this approach, we will study as follows, 1) fabrication of high quality atomically thin layered materials and its artificial hetero-structure, 2) valley-spin generation, detection, and coherent control by advanced optical spectroscopy, 3) realization of valley-spin optical devices.

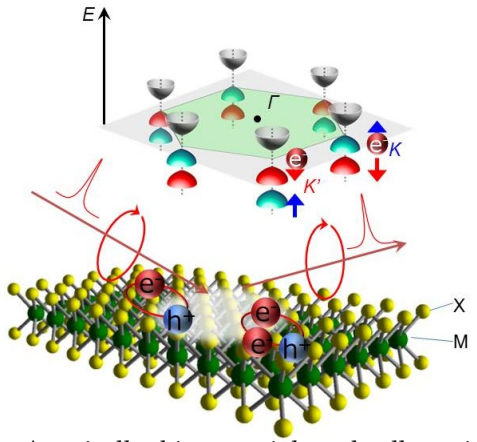

Fig.1 Atomically thin materials and valley-spin photonics

【Expected Research Achievements and Scientific Significance】

In the atomically thin layered materials, the novel quantum optical phenomena will be emerged, because of the huge enhancement of quantum confinement of electrons in the very thin (two-dimensional) layer. We can also apply the valley-spin degree of freedom in these materials. These are based on the new strategy in the material and optical science. Moreover, the low-energy consumption quantum optical devices will be realized by the valley-spin current. Thus, this project is important not only in the viewpoint of fundamental science but also in the future green technology.

【Publications Relevant to the Project】

・D. Kozawa, R. Kumar, A. Carvalho, K. K. Amara, W. Zhao, S. Wang, M. Toh, R. M. Ribeiro, A. H. Castro Neto, K. Matsuda and G. Eda, Photocarrier relaxation pathway in two-dimensional semiconducting transition metal dichalcogenides, Nat. Commun. **5**, 4543 (2014).
・Y. Miyauchi, M. Iwamura, S. Mouri, T. Kawazoe, M. Ohtsu, and K. Matsuda, Brightening of excitons in carbon nanotubes on dimensionality modification, Nat. Photonics **6**, 715 (2013).
・S. Mouri, Y. Miyauchi, and K. Matsuda, Tunable photoluminescence of monolayer MoS_2 via chemical doping, Nano Lett. **13**, 5944 (2013).

【Term of Project】 FY2016-2020

【Budget Allocation】 142,800 Thousand Yen

【Homepage Address and Other Contact Information】

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