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

Science and Engineering (Engineering I)

Title of Project : Development of Key Technologies for the Multi-probeSpectroscopy based on Near-field Optics

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Research Area : Engineering

Keyword : Optical properties, Semiconductor, Micro- and Nano-optics, Optical sensing, Scanning probe microscopy

【Purpose and Background of the Research】

Microspectroscopy such as cathode-luminescence (CL) and scanning near-field optical microscopy (SNOM) has been developed mainly focused on how to photo-excite in a small area. Therefore, the spatial resolution is limited in many cases by the carrier diffusion processes, detailed characterization technique of which has not been realized yet.

In this research project, we aim at the development of multi-probe technique based on near-field optics, by which optical access can be achieved to the nanoscopic area not only of microfabricated materials and/or devices but also of living cells, leading to the development of key technologies for the measurements of optical dynamics. Our goal is to construct the useful tool for the characterization of new materials and/or devices, by means of the the visualization technique for carrier dynamics such as diffusion, localization, radiative and nonradiative recombination in nanoscopic space. This can be achieved by the fast analysis of five-dimensional multi-probed data composed of time, areal location, wavelength and signal intensity.

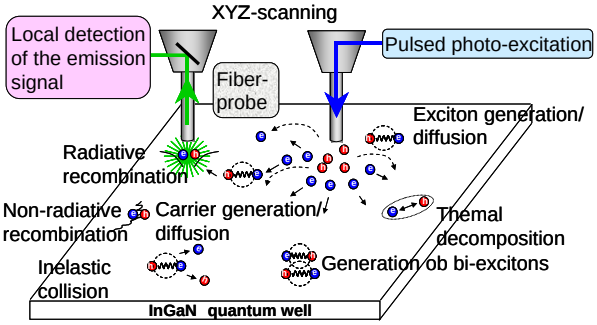

Fig. 1: Multi-probed spectroscopy in near-field optics

【Research Methods】

As a first step, we achieve the detection of both the emission (radiative recombination) and the heat-generation (non-radiative recombination) signals in a single-probed SNOM technique, where the resolutions of space and time are 10nm and 1ps, respectively. We expect that useful information can be obtained such as the spatial extent and the energy depth of localization centers induced by naturally-formed nano-structures in InGaN quantum wells (QWs), and the distribution and capture cross section to non-radiative recombination centers induced by dislocations and/or defects.

In the next step, we aim at the multi-probed technique, where pulsed photo-excitation is made in local area through a fiber-tip having a small aperture, and the time-resolved photoluminescence (PL) signal is detected through other fibers located apart from the photo-excitation fiber with a distance ranging from about a few tens nm to a few μm. Moreover, the technique is going to be achieved for a visualization of the phenomena based on the dynamical interactions in between different locations, by developing the analytical algorithm of multi-dimensional data as a function of time, space and wavelength. We expect that the detailed characterization would be enabled by means of this multi-probe technique for the deep understanding of exciton/carrier dynamics.

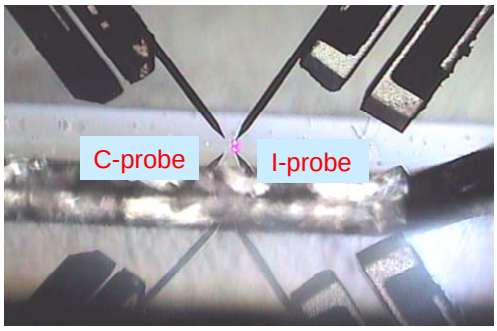

Fig. 2: Prototype of dual-probed SNOM

【Expected Research Achievements and Scientific Significance】

The multi-probed SNOM technique will lead to the development of (a) the spectroscopy of low-dimensional widegap semiconductors, (b) the monitoring of integrated photonic devices such as photonic crystals, and (c) the detection of the functionality in living cells, by which we can search for the new physics of localized excitons in semiconductor nano-structures, and for the mechanism of signal transfer in cells induced by the cooperative interaction in between different space.

【Publications Relevant to the Project】

・A. Kaneta, M. Funato, and Y. Kawakami, “Nanoscopic recombination processes in InGaN/GaN quantum wells emitting violet, blue, and green spectra”, *Phys. Rev. B*, **78**, pp.125317/1 - 7 (2008).

・Y. Kawakami, A. Kaneta, and M. Funato, “Assessment and control of recombination dynamics in $In_xGa_{1-x}N$-based quantum wells”, Materials Sci. Forum **590**, *Advances in Light Emitting Materials*, pp.249-274 (2008).

【Term of Project】 FY2009-2013

【Budget Allocation】 123,900 Thousand Yen

【 Homepage Address and Other Contact Information】

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