International Research Center for Elements Science
- Photonic Elements Science -

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Scope of Research

Our research interest is to understand optical and quantum properties of nanostructures and nanomaterials and to develop opto-nanoscience for creation of innovative functional materials. Optical properties of semiconductor quantum nanostructures and strongly-correlated electron systems in low-dimensional materials are studied by means of space- and time-resolved laser spectroscopy. The main subjects are as follows: (1) Investigation of optical properties of single nanostructures through the development of high-resolution scanning near-field optical microscope, (2) Development of nanoparticle assembly with new optical functionalities, and (3) Ultrafast optical spectroscopy of excited states of semiconductor nanostructures.

Research Activities (Year 2005)

Presentations

Luminescence of Impurity-Doped Semiconductor Nanoparticles (invited), Kanemitsu Y, International Conference on Dynamical Processes in Excited State of Solids, DPC, 1 - 5 August 2005, Shanghai, China.

Direct Observation of Exciton Wavefunction in a Semiconductor Quantum Dot by Near-Field Scanning Optical Microscope (invited), Matsuda K, Annual Meeting of Physical Society of Japan, 24 - 27 March 2005, Chiba, Japan.

Luminescence Properties of Semiconductor Nanoparticles (invited), Kanemitsu Y, The 65th Autumn Meeting of The Japan Society of Applied Physics, 29 March - 1 April 2005, Saitama, Japan.

Light-Emitting Nanoparticles (invited), Kanemitsu Y, The 65th Autumn Meeting of The Japan Society of Applied Physics, 29 March-1 April 2005, Saitama, Japan.

Grants

Kanemitsu Y, Basic Research for Development of Near-Field Optical Microscope for Elemental Analysis and Mass Spectrometry, Grant-in-Aid for Exploratory Research, 1 April 2005 - 31 March 2007.

Matsuda K, Explorer of Optical Properties and Application of Quantum Optical Devices in an Individual Carbon-Nanotube by Optical Nanoprobing, Grant-in-Aid for Young Scientists (A), 1 April 2005 - 31 March 2008.

Matsuda K, Wavefunction Imaging and Control in Semiconductor Nano-structure by Ultimate Optical Nanoprobe, Precursory Research for Embryonic Science and Technology, Japan Science and Technology Agency, 1 November 2002 - 31 March 2006.

Matsuda K, Development of Near-Field Scanning Optical Microscope with Nanometer-Level Spatial Resolution, Research Foundation for Opto-Science and Technology, Research Grant, 1 April 2005 - 31 March 2006.

Matsuda K, Explorer of Properties and Application of Quantum Devices in Carbon-Nanotubes by Optical Nanoprobing, Foundation for C&C Promotion, Research Grant for Young Scientists, 1 April 2005 - 31 March 2006.

Inouye H, Luminescence Dynamics of Self-Assemble Nanocrystal Composite Film and Study for Realizing High Luminescence Efficiency, Grant-in-Aid for Young Scientists (B), 1 April 2005 - 31 March 2007.

Award

Kanemitsu Y, The Ichimura Prize, Pioneering Contributions for Light Emitting Nanoparticles, 28 April 2005.

An Individual Single-Walled Carbon Nanotube Spectroscopy

Single-walled carbon nanotubes have attracted a great deal of attention because of their potential use in electronic devices and their unique physical properties. We investigated photoluminescence properties of individual micelle-encapsulated single-walled carbon nanotubes. Figure 1 shows 3-dimensional plot of a single-walled carbon nanotube photoluminescence image, detected at a range of 1.18 - 1.37 eV at room temperature. Each sharp peak corresponds to the photoluminescence signal from an individual single-walled carbon nanotube. We observed that single photoluminescence peak from isolated individual single-walled carbon nanotube showed a linear increase and saturation behavior of the photoluminescence intensity with an increase of excitation power. We also found unusual photoluminescence intensity fluctuation in the temporal evolutions of the photoluminescence intensity, referred to as photoluminescence intermittency. The photoluminescence intensity fluctuation was seen with some single-walled carbon nanotubes, while the photoluminescence intensity with most single-walled carbon nanotubes remained at a constant amplitude. The photoluminescence intermittency is attributed to the fluctuation of induced local electric field by trapped charges around single-walled carbon nanotubes.

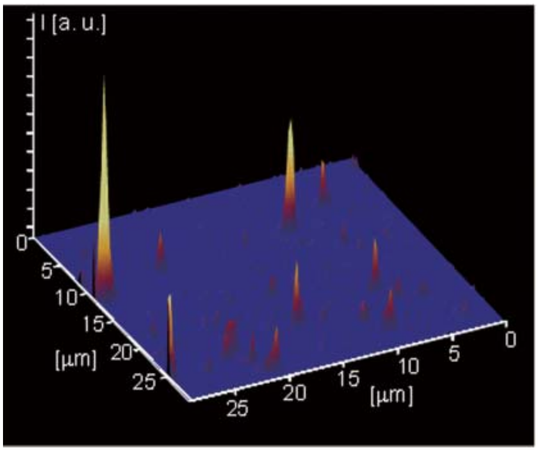

Figure 1. 3-dimensional plot of a single-walled carbon nanotube photoluminescence image by scanning confocal microscopy.

Femtosecond Laser Spectroscopy of Wide Band-Gap Semiconductors

Over the past decade, there have been many experimental and theoretical studies on the optical properties of nitride semiconductors such as GaN, $In_xGa_{1-x}N$, and $Al_yGa_{1-y}N$ crystals. In $In_xGa_{1-x}N$ ternary alloys, efficient photoluminescence (PL) is due to the exciton localization at potential minima. We have clarified the exciton localization processes in $In_xGa_{1-x}N$ ternary alloys by means of optical Kerr-gate time-resolved PL measurements. Figure 2 shows the temporal change of the PL spectra after the femtosecond laser excitation. It is clearly shown that the photogenerated carriers relax to the lower energy state within the 15 ps. Time-resolved PL spectral measurements are one of the most useful methods for understanding the exciton localization dynamics and the radiative recombination processes in semiconductor mixed crystals.

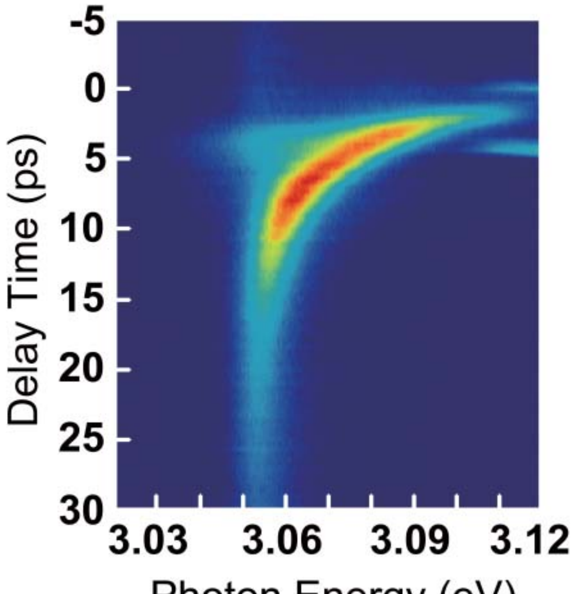

Figure 2. Time-resolved PL spectra of the $In_xGa_{1-x}N$ thin film.