VIEW FROM... JSAP SPRING MEETING 2013

Versatile nanophotonics

Nanophotonics is of both fundamental and applied importance. This field has a wide range of applications, including light-emitting devices and optical integrated circuits.

Noriaki Horiuchi

The Spring Meeting of the Japan Society of Applied Physics (JSAP) was held on 27–30 March 2013 at the Kanagawa Institute of Technology, Japan. The event featured about 3,990 oral and poster presentations and attracted 6,700 researchers from around the world. Nanophotonics was one of the hot topics discussed at the meeting.

As usual, sessions on semiconductor lasers and light-emitting devices (LEDs) attracted a lot of interest. Researchers working on GaN-based LEDs have been trying to enhance light-emission efficiencies and extend emission wavelength ranges to green or deep-ultraviolet wavelengths. Yoichi Kawakami from Kyoto University presented a study of the inhomogeneous energy potentials of GaN-based materials. He wondered why the light intensity and the spectrum from InGaN/GaN LEDs have inhomogeneous spatial distributions, despite the crystalline quality appearing homogeneous in electron microscopy observations. "It might be due to threading dislocations or spatial fluctuations in the indium concentration. However, thus far, no experimental study has identified the cause," Kawakami explained. "The aim of our work is to investigate the behaviour of optically excited electrons in an area as small as a wavelength." His group has developed a dual-probe scanning near-field optical microscope in which one probe is used for optical excitation and the other for detecting emitted light. Kawakami explained how his team have experimentally demonstrated the inhomogeneous spatial distribution of the light intensity emitted from an InGaN/GaN single quantum well. When this sample was illuminated by a 405-nm-wavelength laser beam with a diameter of 0.6 μm, a high-intensity emission region as large as the beam diameter was observed, but it was spatially separated from the illuminated area by a distance of about 1 μm. Based on a numerical analysis they performed, the group speculate that this phenomenon is caused by spatial fluctuations in the chemical composition or in the quantum well thickness.


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Around 6,700 participants attended the 2013 JSAP Spring Meeting at the Kanagawa Institute of Technology.

Although localization of the energy potential is detrimental from the viewpoint of developing high-efficiency InGaN/GaN LEDs, it is advantageous in terms of developing nanoscale optical signal transfer systems, such as optical integrated circuits whose optical components have dimensions much smaller than the diffraction limit of light. This is because localization of the energy potential enables the unidirectional transport of photon energy. Motoichi Ohtsu from the University of Tokyo explained the mechanism of the nanoscale optical signal transfer between quantum dots. "There are two key points. One is that the wave-vector conservation law does not hold in this system because the transmission length of the near-field induced in the vicinity of the quantum dots is much shorter than the wavelength. The other is that the relaxation time of excited photons in quantum dots depends on the volume of the dot. Consequently, photon energy is transferred from a small quantum dot to a large one." He reported the dynamic properties of the optical signal transfer and the feasibility of the application to a non-von-Neumann computer. Many technological challenges still need to be overcome, but optical integrated circuits with sizes smaller than the diffraction limit of light are highly promising for future nanophotonic applications.

Although the study of optical integrated circuits based on quantum dots is still at the proof-of-principle stage, many realistic optical integrated devices have been demonstrated in the field of quantum communications. Furthermore, the material receiving the most attention — silicon — has greater latitude in optical waveguides than conventional materials such as glasses. "Silicon is a more advantageous material than silica because entangled photons can be generated in silicon by nonlinear optical effects. Silicon photonic-crystal waveguides enable unprecedented functions that are unachievable in conventional glass waveguides," said Hiroki Takesue from NTT Basic Research Laboratories. Takesue fabricated an optical buffer for nonclassical photons using a coupled resonator optical waveguide containing 400 cavities and made from silicon photonic crystals. The photonic crystals had a lattice constant of 420 nm and the cavity spacing was 2.1 μm. After passing through the coupled resonator optical waveguide with a total cavity length of 840 μm, the optical pulses had a time delay of 150 ps, which corresponds to 1/59th the speed of light. The nonclassical features of the delayed optical pulses were investigated using single and entangled photons. According to Takesue, this is the first experimental demonstration that nonclassical features are preserved in a slow-light device.

Other areas of nanophotonics, such as near-field imaging, surface plasmons, LEDs and solar cells, were also as popular as ever. The momentum of the nanophotonics community is expected to generate new directions in nanophotonics, in addition to those described above.

The JSAP Autumn Meeting will be held in Kyoto on 16–20 September 2013. ❐

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