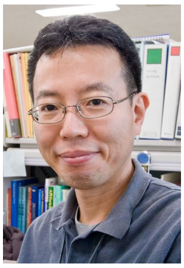
【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Interdisciplinary Science and Engineering)



Title of Project : Novel Photonic Integration Platform with Hybrid Nanophotonics-Nanomaterials Systems

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Research Project Number : 15H05735 Researcher Number : 50393799
Research Area : Applied Physics, Nanophotonics
Keyword : Photonic crystal, Nanowire, Plasmonics, Graphene

【Purpose and Background of the Research】

Recently, nanowires and atomic layer materials (nanofilms), such as graphene, have been realized and extensively studied, which exhibit various novel characteristics. Although some of those nano materials have already been applied to photonic devices, the performance is still limited because their size is much smaller than the wavelength of light. In this study, we propose to realize novel photonic platform which combines nanomaterials with specially designed nanophotonics systems to dramatically enhance the light-matter interactions and to enable them to couple with photonic waveguides/circuits.

【Research Methods】

(1) Hybrid nanowire-photonic crystal systems

Here we employ an artificial nanostructure called “photonic crystal” (PhC), in which the refractive index is periodically modulated in nano-scale. Recently, we have clarified that if we place a nanowire on a groove in a PhC, we can create nanoresonator modes at the nanowire position by which light is strongly confined within the nanowire. Note that PhC nanoresonators can be easily coupled with a waveguide circuit in PhC. In this study, we exploit this method to combine various nanomaterials with PhCs to realize strong coupling between light and nanomaterials.

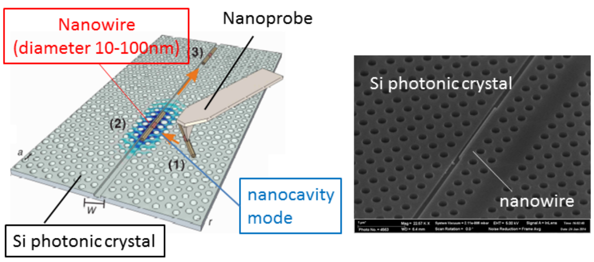

Figure 1 Hybrid nanowire/photonic-crystal system.
Schematic (left) and electron micrograph image (right).

(2) Hybrid nanowire-plasmonics systems

We employ yet another artificial nanostructure called plasmonic waveguides. By this structure, we can confine light within a gap sandwiched between two metal regions by collective resonance of conducting electrons. Light can be confined in even smaller area than in (1). In this study, we place ultrasmall nanomaterials within the gap of the plasmonic waveguide. Since this unique property can be maintained even after we place nanomaterials, we can utilize this method to create strong light-nanomaterial coupling. Note that both of (1) and (2) can be applied to nanofilms as well.

(3) Nanomanipulation techniques

In order to realize (1) and (2), we exploit nanomanipulation techniques to place nano materials at arbitrary position.

【Expected Research Achievements and Scientific Significance】

Our method is generally applicable to a wide variety of nanowires and nanofilms. We expect that it will provide us to a novel route to photonic device applications of nanomaterials, and it will play a role as a novel platform to realize strong light-matter interactions in nanomaterials.

【Publications Relevant to the Project】

・M. D. Birowosuto et al., “Movable high-Q nano resonators realized by semiconductor nanowires on a Si photonic crystal platform”, Nature Materials 13, pp. 279-285 (2014).
・M. Notomi, "Manipulating light with strongly modulated photonic crystals", Reports on Progress in Physics 73, 096501 (2010).

【Term of Project】 FY2015-2019

【Budget Allocation】 142,600 Thousand Yen

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