【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Chemistry)

Title of Project : Spatio-temporal characteristics and control of coupled excited states in nano-dot arrays

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Research Area : Chemistry

Keyword : Nanometrology, Scanning probe microscopy, Surface / interface

【Purpose and Background of the Research】

Nano-sized materials show peculiar characteristics different from both macro-sized and molecular-level materials, and are expected to open new evolution in technologies of 21st century. Excited states are of fundamental importance in developing novel characteristics of nanomaterials. By the proper design and control of excited-state characters of the nanostructures, we may deliver light to a targeted confined space, induce molecular excitations that cannot occur in the conventional environments, for example, or construct nanometric information devices utilizing these features. To realize and develop them, we need to analyze the nano-scale spatial structures of the light field, but we cannot do it with the conventional microscope. In this project, we adopt near-field microscopy to directly observe the nanometric optical and spectroscopic features of the materials fabricated, and perform model calculations to analyze the result. In this way, we reveal the correlation between the nanostructures and the characters of the excited-states, and construct new concepts to develop novel characteristics and to control optical and excited-state fields in nanospaces.

【Research Methods】

We fabricate nanomaterial samples with designed structures and configurations by electron-beam lithography. We begin the project with studying noble metal nanostructures, especially circular disks and circular voids on metal thin films (collectively called here as "circular nanodots") and arrayed structures of them. The nanoscale optical imaging of the fabricated samples is performed with a near-field microscope to get spatial distributions of optical fields on the nanostructures. The experimental data of optical field structures are analyzed on the bases of electromagnetic theoretical simulations or simpler physical model calculations. We will also extend the target to semiconductors, polymers, etc. on which we can expect further interesting excited-state characteristics, and investigate generality and uniqueness of the observed features.

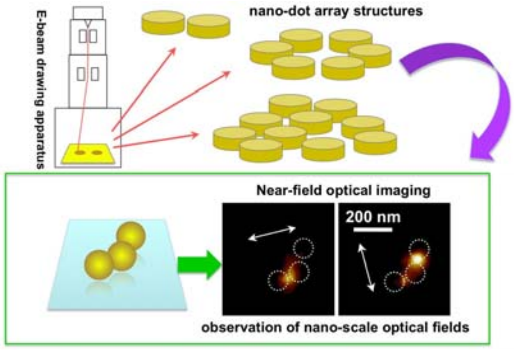

Figure. Procedure of the research: fabricate nanostructures with electron-beam lithography, and observe them with near-field imaging.

【Expected Research Achievements and Scientific Significance】

This research project will reveal the basic principle determining (and as a result may give guidelines to design and control) the space-time structures of optical and excited-state fields in nanomaterials. It may further contribute to find novel photo-physical and -chemical phenomena that take place only in suitably designed nanomaterials, or to develop highly sensitive chemical analysis methods, various photoresponsive materials, optical information transmission and processing devices, and so forth.

【Publications Relevant to the Project】

・Hiromi Okamoto and Kohei Imura, "Near-field optical imaging of enhanced electric fields and plasmon waves in metal nanostructures," *Prog. Surf. Sci.* 84, 199-229 (2009).

【Term of Project】 FY2010-2014

【Budget Allocation】 119,300 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.ims.ac.jp/know/light/okamoto/okamoto.html