Plasmonic Nanoarchitectonics for Energy Conversion

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Plasmonics and metamaterial are the new emerging paradigms for materials science which enable us to control the light in nano-space. Through this concept we have been developing materials with extraordinary signal enhancement of molecules, enhanced photocatalytic reaction, and efficient solar power harvesting. Currently, increasing interest exists in the field of solar heat energy conversion as well as in molecular sensing. Thanks to the rapid improvements in the bottom-up and top-down nanofabrication techniques in the past decade, dramatic progresses have been achieved in this field. Here in our laboratory we aim at manipulating the infrared light waves for enhancing the applications in environmental monitoring as well as solar and thermal energy conversion by developing new metallic and metallodielectric nano-structures. In this talk I will present some of the fundamental aspects and advantages of plasmonic resonators with both narrow-band and broad-band optical response, with emphasis on the dimensionality effects and nanogap geometry. Plasmonic nano-absorbers offers chances to realize high-efficiency light absorption with flexible spectrum engineering. In this talk, we report our recent research on the fabrication and characterization of plasmonic light scavengers/absorbers for the potential application in photocatalysis, plasmon-enhanced vibrational sensing for in situ water sensing, as well as light-heat transducers. Here we will exemplify nanogap-based molecular sensors and three dimensional broadband light absorbers/scatterers prepared by wet chemistry as well as lithographic fabrication. Toghether with numerical electromagnetic simulations, we showcase various fabrication methods using electron-beam lithography, photolithography, as well as colloidal templating process and nano-mechanical process for the large-area fabrication.

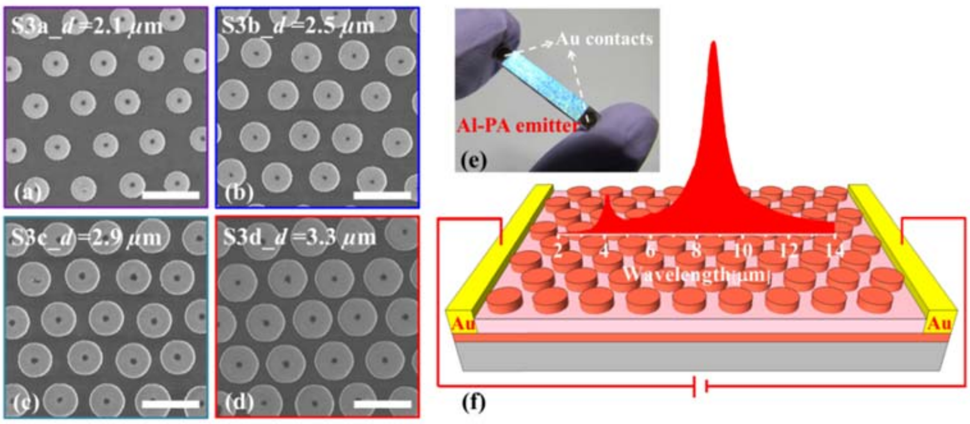

Figure. (a-d) SEM images of the metmaterial perfect absorvers. The scale bar in each image is 5 μm. (e) A photo of a typical metamaterial thermal emitter device. (f) Schematic of a thermal emitter device having two Au electrodes.

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Education

1990, B. Sc., Department of Physics Waseda University (Condensed Matter Theory).
1992, M. Sc., Department of Physics Waseda University (Surface Physics)
1995, D. Sc., Waseda University, "Development and application of high-performance electron energy loss spectrometers for surface phonon spectroscopy"

Professional Experience

1994 -1994	Research Associate, Waseda University.
1994 -2001	Assistant Professor, Department of Physics, University of Tokyo.
2000 -2003	Principal Investigator, Precursory Research for Embryonic Science and Technology (PRESTO), Japan Science and Technology Agency (JST).
2001 -2004	Associate Professor, Institute for Materials Research, Tohoku University.
2004 - 2007	Subgroup Leader, Senior Scientist , National Institute for Materials Science.
2008 - 2009	Visiting Scientist, School of Engineering and Applied Sciences, Harvard University.
2007 - 2010	Senior Scientist (Independent Scientist), International Center for Materials Nanoarchitechtonics, National Institute for Materials Science.
2011 - present	Group Leader, Nano-system Photonics Group, International Center for Materials Nanoarchitectonics, National Institute for Materials Science, Fellow (FInstP) of the Institute of Physics (United Kingdom).

Fields of Research

Surface Physics, Nanophotonics, Nanomaterials

Publications

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3. L. Liu, T. D. Dao, R. Kodiyath, Q. Kang, H. Abe, **T. Nagao**, and J. Ye, "Plasmonic Janus-Composite Photocatalyst Comprising Au and C–TiO_2 for Enhanced Aerobic Oxidation over a Broad Visible-Light Range," Advanced Functional Materials, Adv. Funct. Mater. **24**, 7754–7762 (2014).
4. Jung-Sub Wi, Satoshi Tominaka, and **Tadaaki Nagao**, "Arrays of Nanoscale Gold Dishes Containing Engineered Substructures," Advanced Optical Materials **1**[11], 814-818(2013).
5. Chung V. Hoang, Makiko Oyama, Osamu Saito, Masakazu Aono, **Tadaaki Nagao**, "Monitoring the Presence of Ionic Mercury in Environmental Water by Plasmon-Enhanced Infrared Spectroscopy," Scientific Reports **3**, Art. No.: 1175 (2013).