Fabrication and application of plasmonic materials

- Takeyasu group -
Faculty of Science

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Research activities

1) Self-assembly/growth for metallic nanostructures

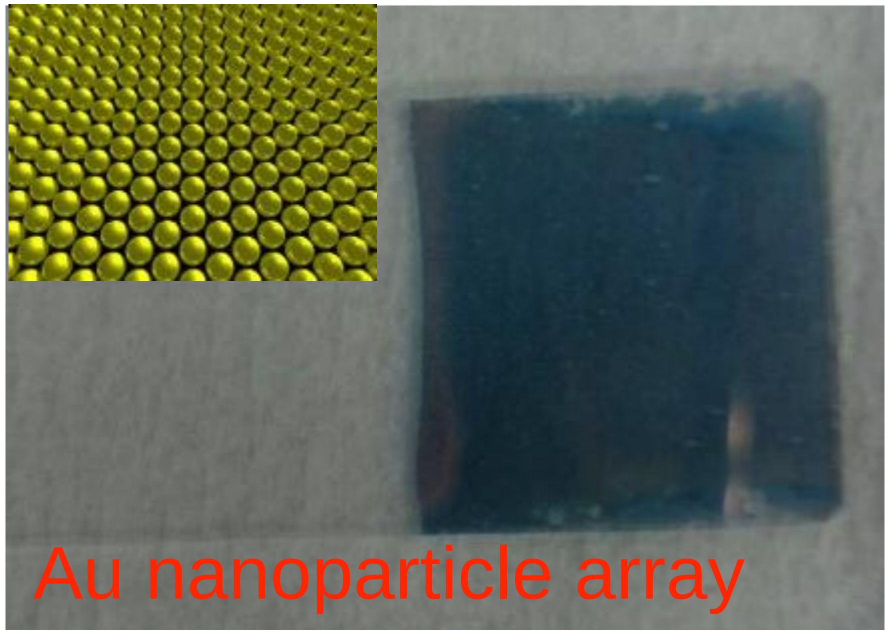
1) Plasmon-induced chemical reaction

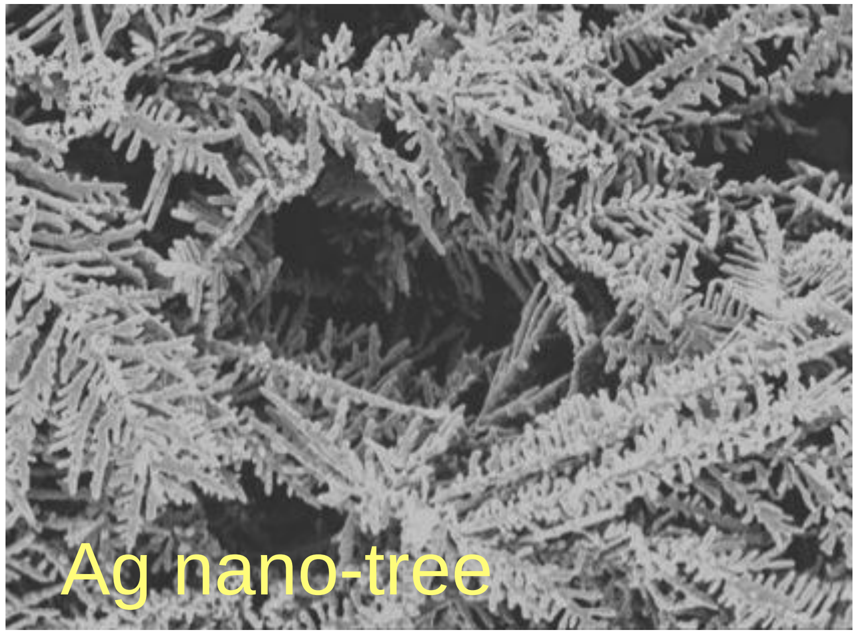
2) Surface-enhanced Raman scattering (SERS)

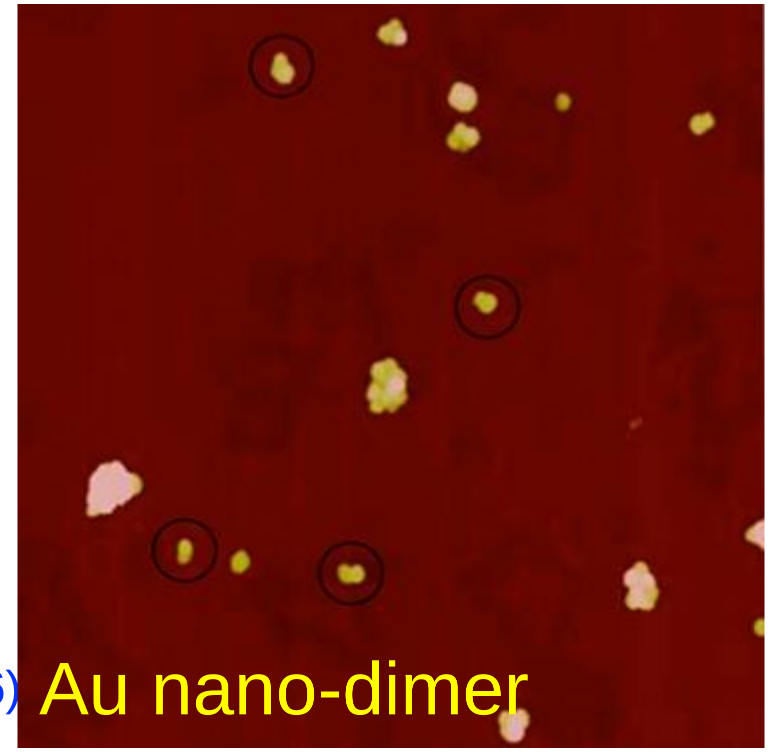
Self-assembly/growth for metallic nanostructures

Metallic nanostructures show interesting optical properties because of surface plasmon polaritons. These structures are applicable to optical filters, sensing method, index control, and so on. The optical properties are determined also by the shape in nanoscale. For practical applications, it is desired to fabricate such metallic nanostructure over bulk scales.

Objective: Self-assembly/growth for such metallic nanostructure with a wide variety of shapes





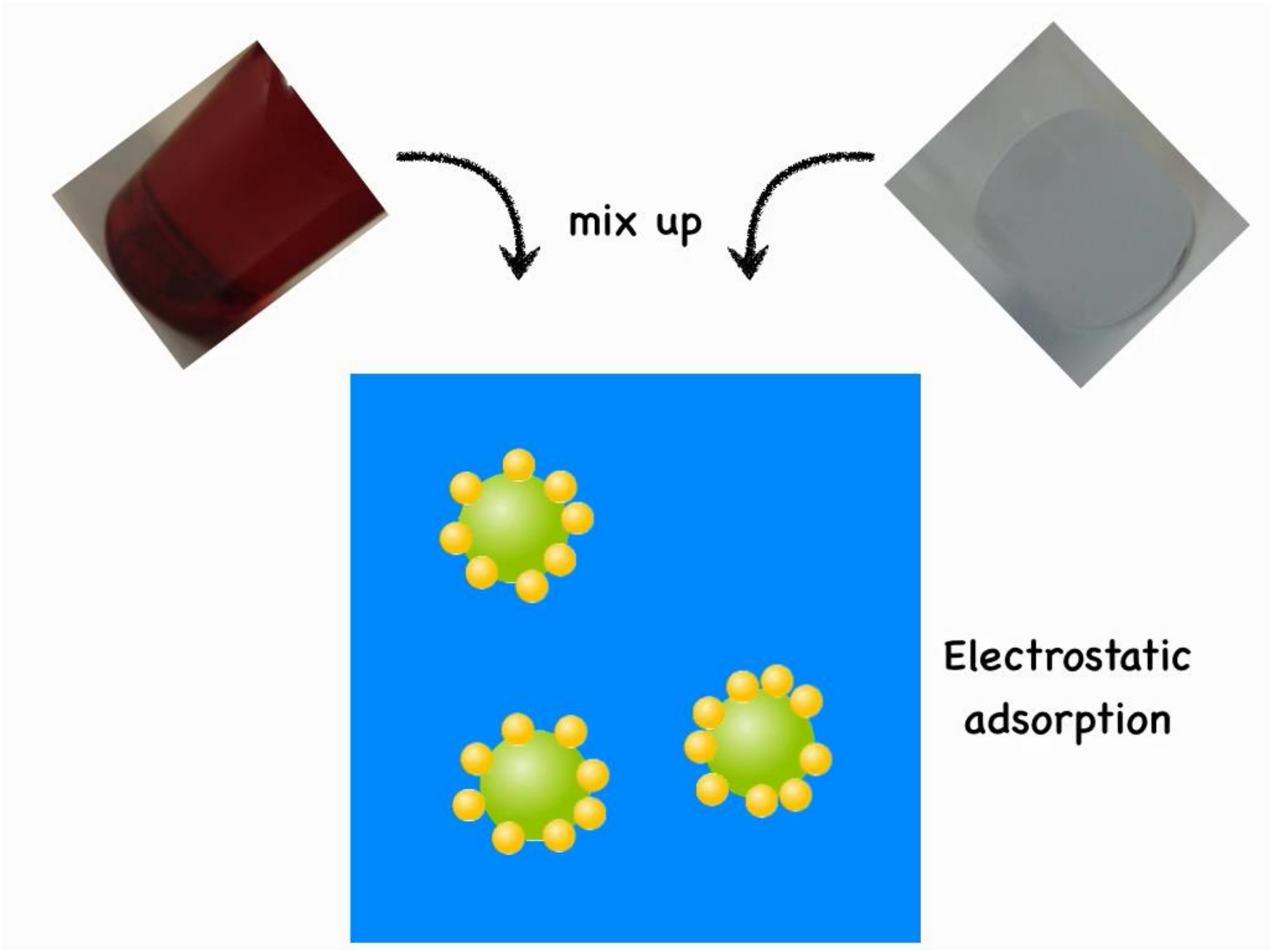


R. Kagawa, N. Takeyasu, T. Kaneta, Y. Takemoto, Appl. Phys. Express **9**, 075003 (2016).

N. Takeyasu, N. Taguchi, N. Nishimura, B.H. Cheng, S. Kawata, APL Photonics **1**, 050801 (2016).

S. Ikegami, N. Takeyasu, T. Tanaka, T. Kaneta, (submitted).

An innovative and low cost method to grow smooth thin films of gold nanoparticles



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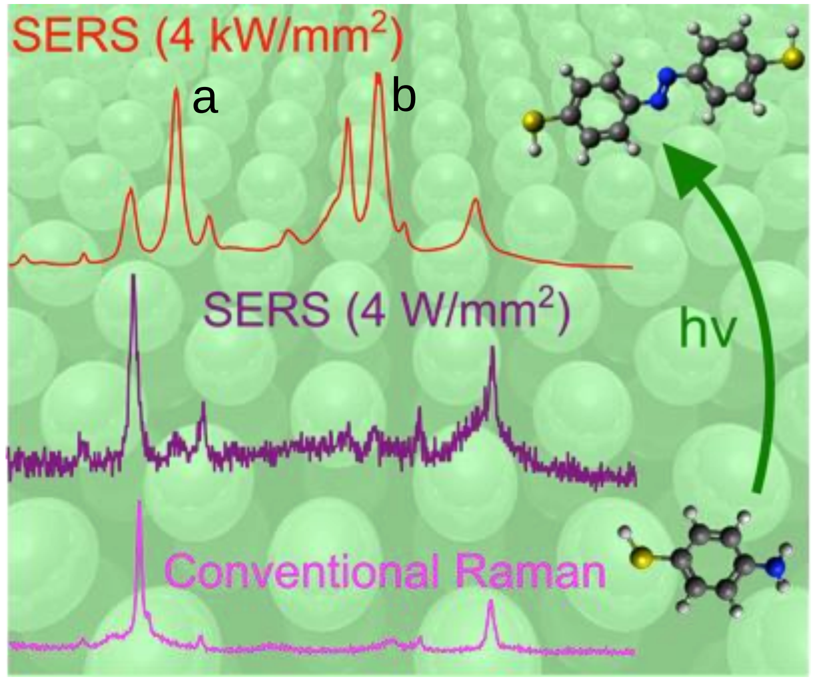
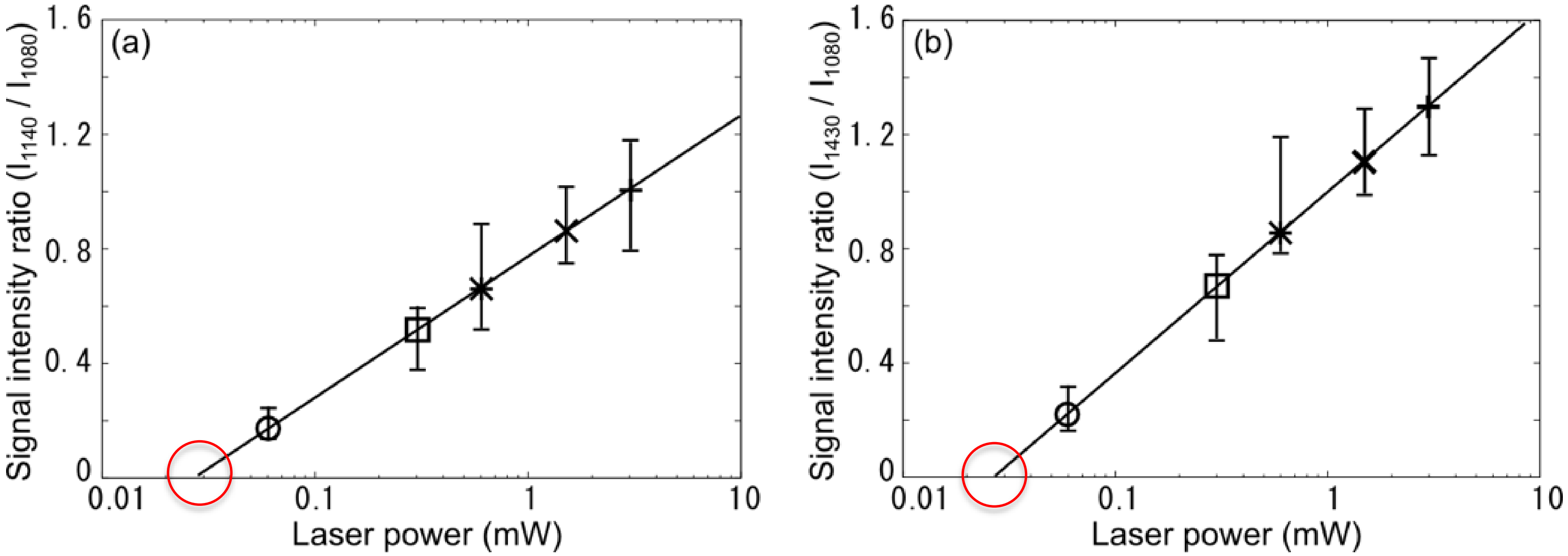
Plasmon-induced chemical reaction

Light can be enormously enhanced at the surface of nano-metals: this crucial property was used in plasmon-induced chemical reaction, surrface-enhanced spectroscopy, etc.

Objectives: Investigation of plasmon-induced chemical reactions



para-Aminothiophenol (*p*-ATP) was measured on AgNP array. It was observed that chemical reaction from *p*-ATP to dimercaptoazo-benzene (DMAB) was induced during SERS measurement.



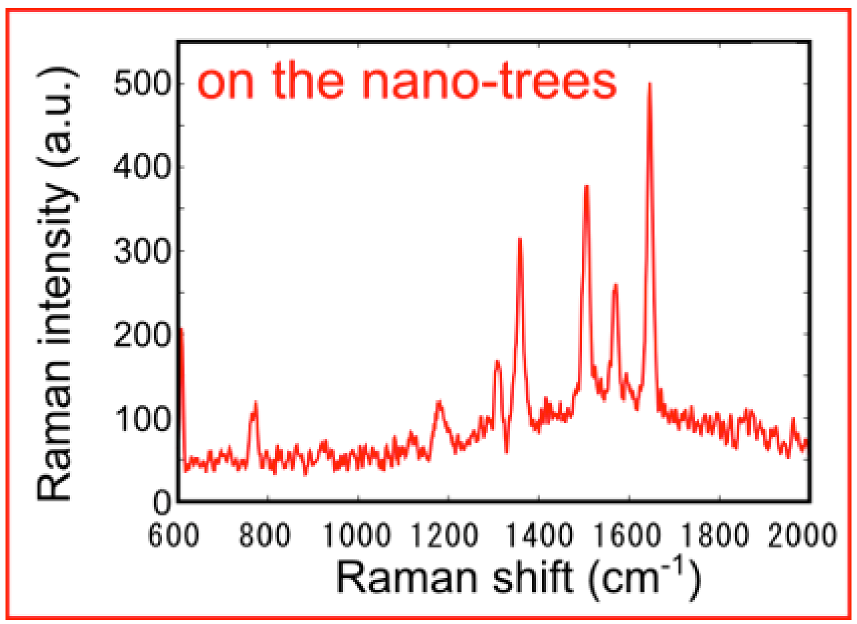
Raman peaks of DMAB were observed at 1140, 1390 and 1430 cm^{-1}. The peak intensity ratios were plotted with different laser powers at (a)1140 cm^{-1} and (b)1430 cm^{-1} (compared to the peak at 1180cm^{-1}). From these results, it was estimated that the chemical reaction from *p*-ATP to DMAB occurs at more than ~0.028 mW.

N. Takeyasu, et al., J. Phys. Chem. C **120**, 12163 (2016).

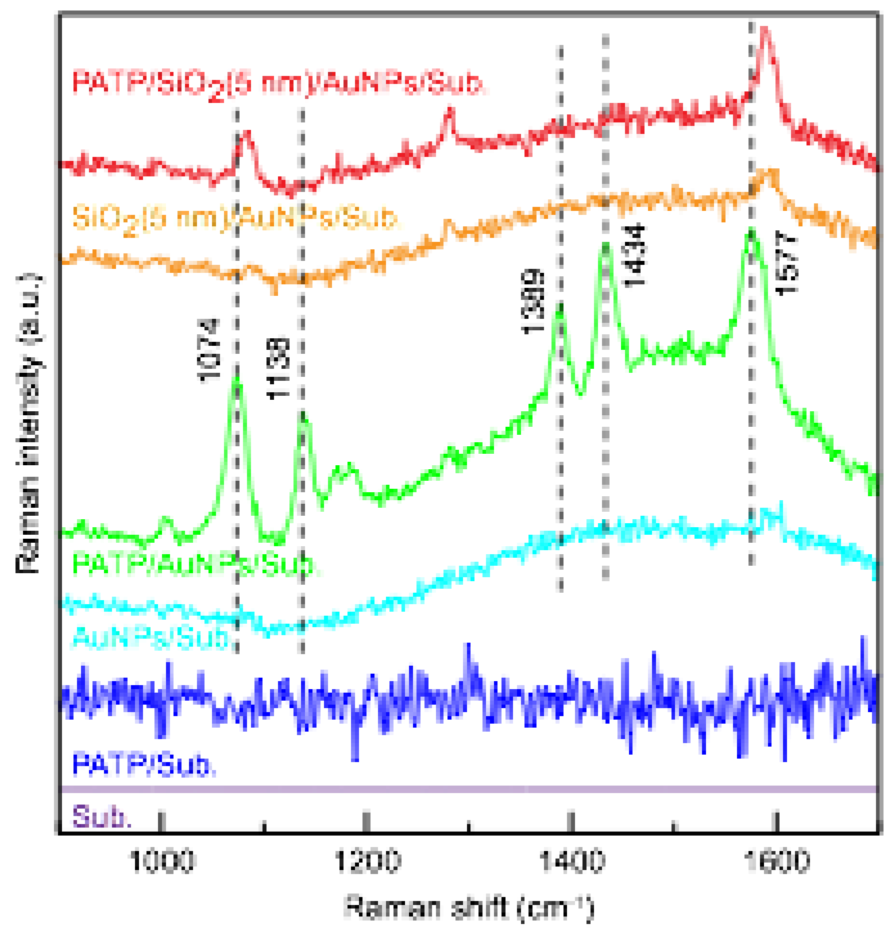
Surface-enhanced Raman scattering (SERS)

Light can be enormously enhanced at the surface of nano-metals, which enables high-sensitive chemical sensing. However, it was afraid that some analytes, for instance, *p*-ATP, were transformed into different molecules during SERS measurement.

Objectives: Development of high-sensitive analytical method



SERS spectrum of Rhodamine6G on silver nano-trees. Fluorescence was quenched, and the signals were enhanced by ~5×10[6].



para-Aminothiophenol (*p*-ATP) was measured on AuNP array covered with thin SiO_2, which was effective to prevent the chemical reaction.

N. Takeyasu, et al., APL Photonics **1**, 050801 (2016).

N. Takeyasu, K. Yamaguchi, R. Kagawa, T. Kaneta, F. Benz, M.Fujii, J. J. Baumberg (submitted).

Takeyasu Gr. International Projects

ASCENT

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Coordinator : Dr. Nicolas Cordero Nicolas.Cordero@tyndall.ie

"Characterisation of 2D metal nanoparticle array"

We have been working on surface-enhanced Raman scattering/spectroscopy (SERS). Noble metallic nano-surface are required for SERS substrate. We are developing the SERS substrate now.
Gold/silver nano-particle arrays (single layer) have been shown to work as excellent SERS substrates exhibiting Raman **enhancement of 10^4 ~ 10^5**.

To increase the enhancement, we would like to make double layer and evaluate the optical properties ---- Job performed at Tyndall in April 2017.

Specific gain expected at ASCENT (Tyndall) platforms

Raman microscope equipped with a 633 nm excitation laser at Tyndall – 532 & 785 nm at OU.
Only silver nanoparticle array has been used so far.
The 633 nm laser allows using gold nanoparticle single/ double layer as SERS substrate.

Takeyasu Gr. Members (y-2017)

1 MD student (Metafluid)

2 BD students (SERS, nano-dimer)

International students

1 internship student (MD), Grenoble-Alpes University – France -
Duration: May 2017 - Aug. 2017

*** Thermal deformation of Au nanorod**

Recent papers

1) R. Kagawa, N. Takeyasu, T. Kaneta, Y. Takemoto, “Oil-in-water emulsion as fabrication platform for uniform plasmon-controlled two-dimensional metallic nanoparticle array,” Appl. Phys. Express **9**, 075003 (2016).
2) N. Takeyasu, R. Kagawa, K. Sakata, T. Kaneta, “Laser Power Threshold of Chemical Transformation on Highly Uniform Plasmonic and Catalytic Nanosurface,” J. Phys. Chem. C **120**, 12163 (2016).
3) Invited Article: N. Takeyasu, N. Taguchi, N. Nishimura, B.H. Cheng, S. Kawata, “Plasmonic growth of patterned metamaterials with fractal geometry,” APL Photonics **1**, 050801 (2016).