14th International Conference on Plasma Based Ion Implantation & Deposition

PBII&D 2017

New World Shanghai Hotel

October 17-20, 2017, Shanghai, China

Program

Organized by

Shanghai Institute of Ceramics, Chinese Academy of Sciences (SIC CAS)
Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences (SIMIT CAS)

14th PBII&D Committees

Organizer

Shanghai Institute of Ceramics, Chinese Academy of Sciences
Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences

International Organizing Committee

P. K. Chu (Chairman)	Hongkong, China
M. Bilek	Australia
N. Huang	China
S. Mändl	Germany
A. Márquez	Argentina
L. Pichon	France
X. B. Tian	China
M. Ueda	Brazil
R. H. Wei	USA

Local Organizing Committee

Xuanyong Liu (Chair)	Shanghai Institute of Ceramics, CAS
Zengfeng Di (Co-Chair)	Shanghai Institute of Microsystems and Information Technology, CAS
Yongfeng Mei	Fudan University
Zhenghua An	Fudan University
Zhongying Xue	Shanghai Institute of Microsystems and Information Technology, CAS
Huiliang Cao	Shanghai Institute of Ceramics, CAS

ID 27

Evaporative self-assembly of gold nanorods into macroscopic 3D plasmonic superlattice arrays for SERS detection

Penghui Li[1], Xue-Feng Yu[1], Paul K. Chu[2]

[1] Center for Biomedical Materials and Interfaces,
Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences,
No.1068 Xueyuan Avenue, Nanshan District, Shenzhen, 518055, China;
[2] Department of Physics & Materials Science, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong, China

Keywords: Self-assembly, gold nanorods, plasmonics, 3D superlattice

Introduction: The buildup of 3D superlattice with collective electro-optical properties by ordered self-assembly of nanoparticles has become the cutting-edge technology in the research field of nanomaterials [1]. Droplet evaporative self-assembly is a simple and effective technique is to build the superlattice structure. However, the well-known coffee-ring effect seriously hinders the ordered packing of the nanoparticles. A strategy to totally suppress or even reverse the coffee-ring effect is highly desirable in order to accomplish homogenous self-assembly of nanoparticles into a macroscopic structure [3].

Materials and Methods: The surface chemistry of gold nanorods and substrate were regulated to achieve the reversing of coffee-ring effect during the evaporative self-assembly [3]. The evaporative self-assembly processes with different parameters were recorded, and the deposition behaviors of gold nanorods during evaporation were analyzed. The morphology and structure of the obtained 3D superlattice were observed with confocal laser scattering microscopy and scanning electron microscopy (SEM). The plasmonic properties of the 3D superlattice array were determined in surface-enhanced Raman scattering (SERS) with malachite green (MG) as the model analyte.

Results and Discussion: The results demonstrated that the coffee-ring effect has been completely reversed and consequently, homogenous deposition is achieved based on the combined effects of Marangoni flow and contact line receding. All the gold nanorods are dense, regular, and nearly vertically aligned with respect to the surface of the substrate, and form the homogeneous macroscopic 3D superlattice array (Figure 1). The SERS detection of MG with this superlattice array exhibit sensitive and reproductive results, with the detection limit down to 1.0×10^{-10} M and reproducibility lower than 10% (Figure 2).

Conclusion: Millimeter-scale 3D superlattice arrays composed of dense, regular, and vertically aligned gold nanorods have been fabricated and demonstrated excellent SERS sensitivity and reproducibility. Such 3D organization of gold nanorods into macroscopic superlattices results in excellent plasmonic substrates suitable for macroscopic sensing applications. This reproducibility and operability of the droplet evaporation strategy can be readily extended to the self-assembly of various plasmonic nanoparticles into macroscopic 3D superlattice arrays and bridge the gap between nanoscale materials and macroscopic applications [4].

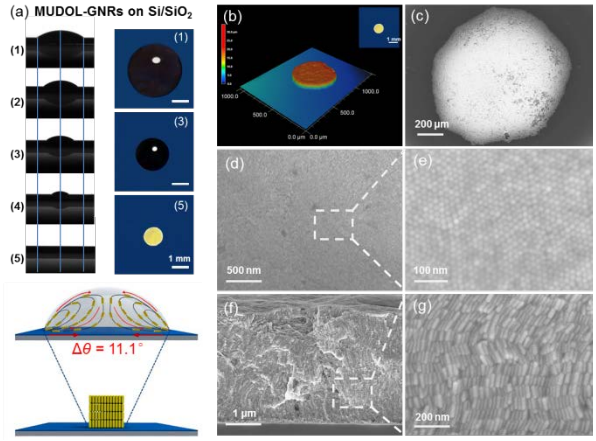

Figure 1 (a) Evaporation process and deposition behavior of gold nanorods during evaporative self-assembly; (b-g) Morphology and structure of the obtained gold nanorods 3D plasmonic superlattice array [3].

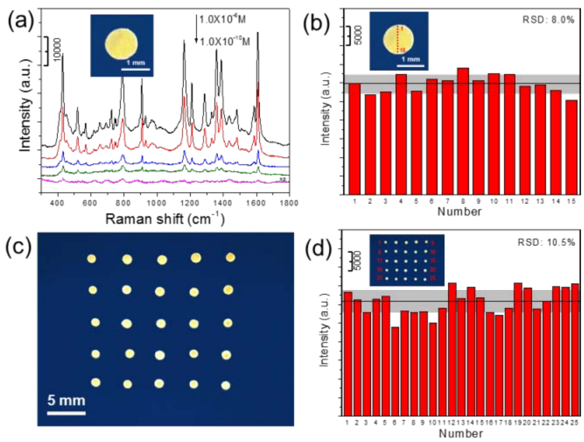

Figure 2 SERS detection performance of MG molecules with the gold nanorods 3D plasmonic superlattice array [3].

References:

[1] W Lewandowski, M Fruhnert, J Mieczkowski, C Rockstuhl, E Górecka. Dynamically self-assembled silver nanoparticles as a thermally tunable metamaterial. Nature Communications, 2015, 6: 6590.

[2] VR Dugyala, MG Basavaraj. Control over coffee-ring formation in evaporating liquid drops containing ellipsoids. Langmuir, 2016, 30: 8680-6.

[3] PH Li, Y Li, Z-K Zhou, SY Tang, X-F Yu*, S Xiao, ZZ Wu, QL Xiao, YT Zhao, HY Wang, PK Chu*. Evaporative self-assembly of gold nanorods into macroscopic 3D plasmonic superlattice arrays. Advanced Materials, 2016, 28: 2511-7.

[4] SY Tang, Y Li, H Huang, PH Li*, ZN Guo, Q Luo*, Z Wang, PK Chu, J Li, X-F Yu*. Efficient enrichment and self-assembly of hybrid nanoparticles into removable and magnetic SERS substrates for sensitive detection of environmental pollutants. ACS Applied Materials and Interfaces, 2017, 9: 7472-80.

Corresponding:

Email: xf.yu@siat.ac.cn

Tel: 86-755-86392212

Fax: 86-755-86585222