





Outline

- 1. Plasmonic Metamaterials Background
- 2. Structures of plasmonic metamaterials that works in visible light region
- 3. Two different fabrication techniques for 3D metamaterials
- Two-photon-induced metal ion reduction - Self-organization process using DNA template









light propagation is limited/determined by the variety of refractive indices of materials.











Change of effective mass of electron -> change $\omega_{\rm P}$ -> change ε Electron's oscillation (Current flow) -> change μ 9 ∞





















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3D metal structures.





























































Ohshiro, T.; Zako, T.; Watanabe-Tamaki, R.; Tanaka, T.; Maeda, M. Chem. Commun., 2010, 46, 6132-6134.















Conclusion Brief introduction of plasmonic metamaterials Fabrication techniques for 3D metamaterials Two-photon reduction technique. Inhibition of crystallization of metal is crucial Self-organized formation of metal ring structure using DNA-templates





















reference

J. Phys. Chem. B 2006, 110, 12302-12310

Plasmon Modes of Nanosphere Trimers and Quadrumers

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Figure 9. Electric field enhancements of a 10 nm silver trimer with a separation of 1 nm as calculated by PDTD. The top panel shows the extention cross-section of this system, and the bottom forus panels show the electric field enhancement for the wavelengths indicated by the legends in the top panel. The incoming light is polarized along the *x*-axis. The simulation uses a a cell-size of 0.25 nm and the same parameters as Figure 7 for the silver metal.



Relationship between ring structure and shape of AuNP				
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Uniformity of the spherical shape of AuNP increases the yield of the triangle.	•	* •	•	