Elbahri, Mady; Abdelaziz, Moheb; Homaeigohar, Shahin; Elsharawy, Abdou; Keshavarz Hedayati, Mehdi; Röder, Christian; El Haj Assad, Mamdouh; Abdelaziz, Ramzy

Plasmonic Metaparticles on a Blackbody Create Vivid Reflective Colors for Naked-Eye Environmental and Clinical Biodetection

Published in:
Advanced Materials

DOI:
10.1002/adma.201704442

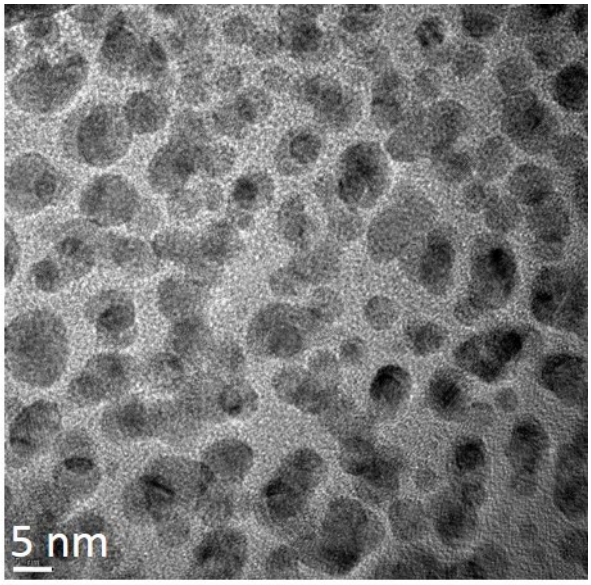
Published: 01/01/2018

Supporting Information

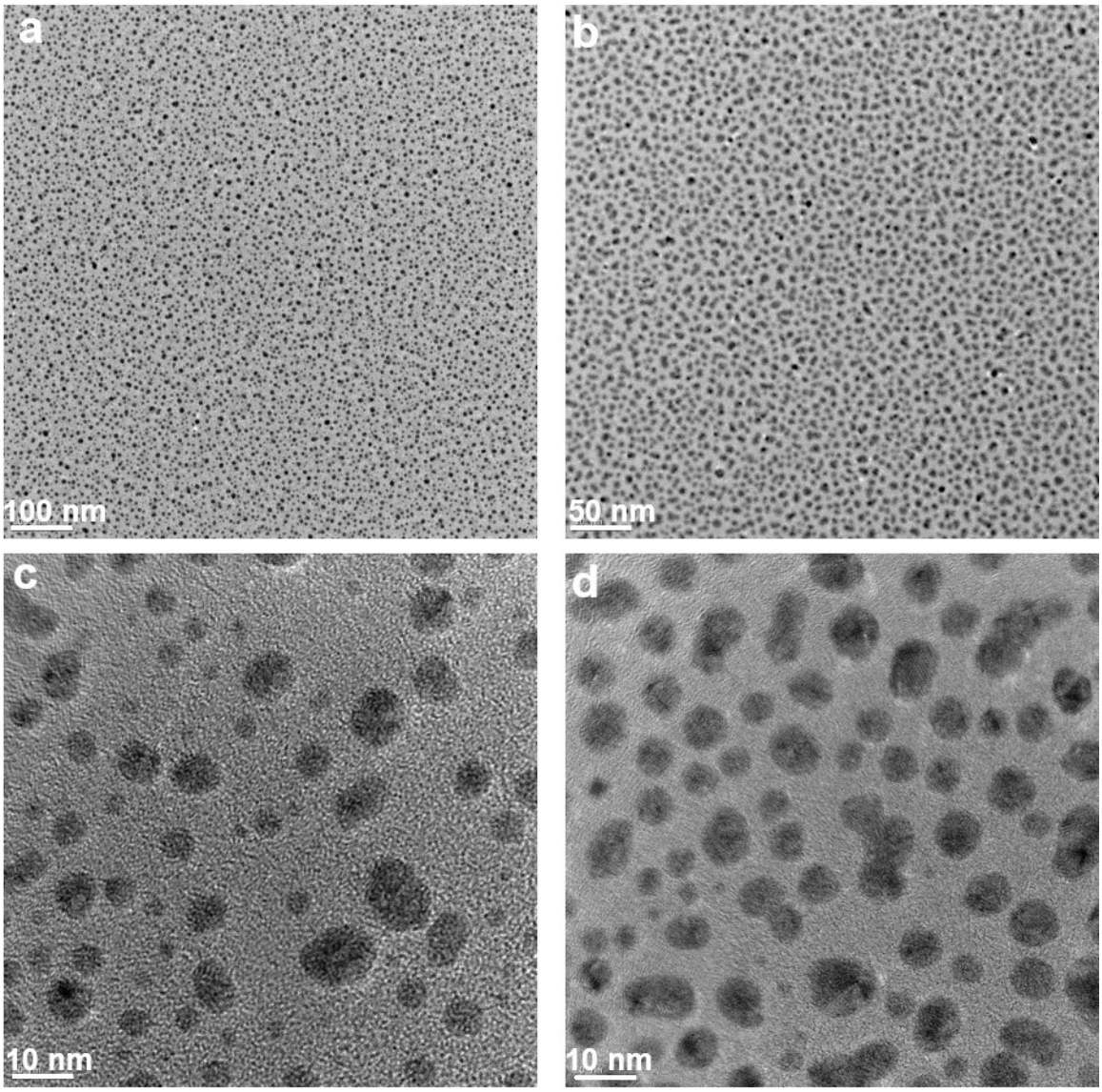
Plasmonic Metaparticles on a Blackbody Create Vivid Reflective Colors for Naked-eye Environmental- and Clinical Bio-detection

Mady Elbahri [*], *Moheb Abdelaziz, Shahin Homaeigohar, Abdou Elsharawy, Mehdi Keshavarz Hedayati, Christian Röder, Mamdouh El Haj Assad, and Ramzy Abdelaziz*

Prof. M. Elbahri, M. Abdelaziz, Dr. S. Homaeigohar, Dr. R. Abdelaziz
Nanochemistry and Nanoengineering, School of Chemical Engineering, Department of Chemistry and Materials Science and Engineering, Aalto University, Kemistintie 1, 00076 Aalto, Finland.
E-mail: mady.elbahri@aalto.fi ,Tel.: +358-50-431-9831.
Prof. M. Elbahri, M. Abdelaziz, Dr. M. Keshavarz Hedayati
Nanochemistry and Nanoengineering group, Institute for Materials Science, Faculty of Engineering, University of Kiel, Kaiserstrasse 2,24143 Kiel, Germany.
Prof. M. Elbahri
Zewail City of Science and Technology, Sheikh Zayed Dist., 12588 Giza, Egypt.
Dr. M. Keshavarz Hedayati
Department of Micro- and Nanotechnology, Technical University of Denmark, Kongens Lyngby DK-2800, Denmark.
Dr. A. Elsharawy, Dr. C. Röder
Institute of Clinical Molecular Biology, University of Kiel, Kiel, Germany.
Dr. A. Elsharawy
Faculty of Sciences, Division of Biochemistry, Chemistry Department, Damietta University, New Damietta City, Egypt.
Dr. M. El Haj Assad
SREE Department, University of Sharjah, 27272 Sharjah, United Arab Emirates.

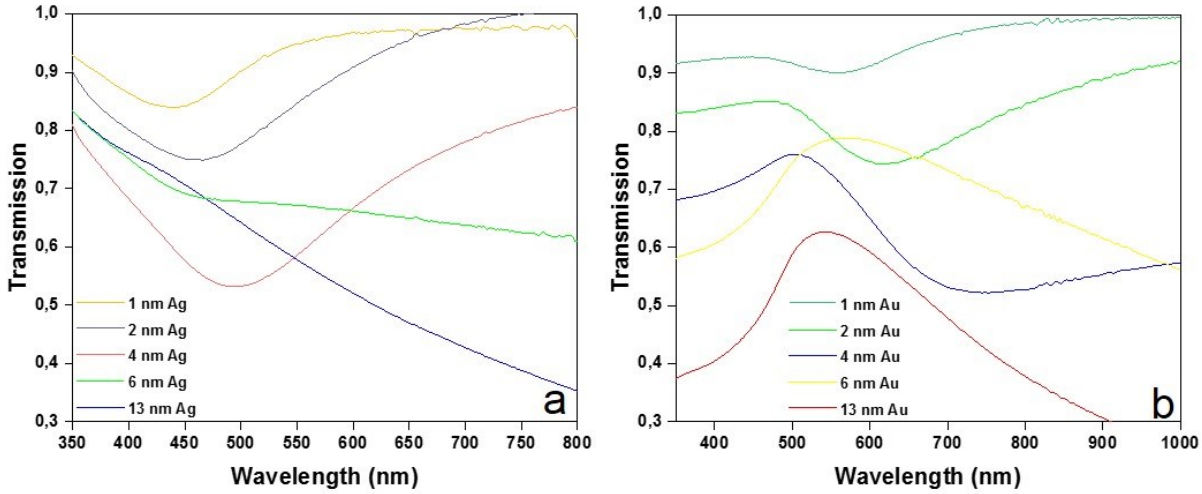


Supplementary Figure 1. TEM image of Ag nanoparticles dispersed in a SiO_2 matrix.

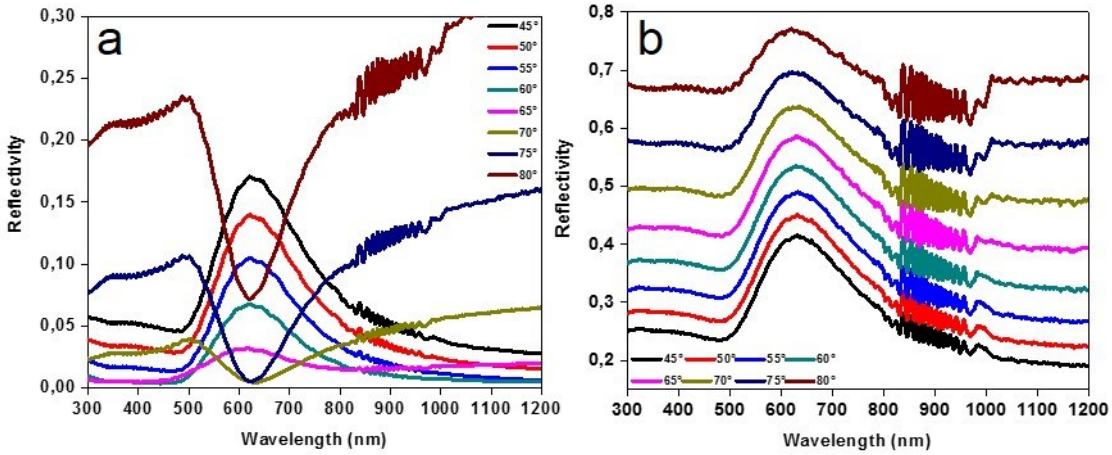


Supplementary Figure 2. TEM images demonstrate the shape, size distribution and interparticle spacing of Ag nanoparticles when the Ag thickness is 3 (a&c) and 5 nm (b&d) at different magnifications.

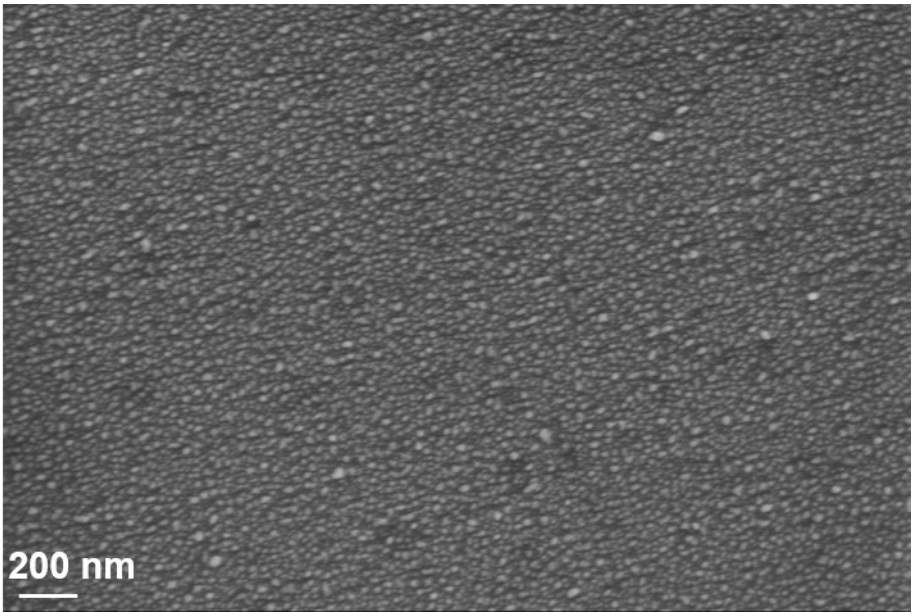
We investigated the effect of the plasmonic metamaterial thickness to determine the critical cluster size able to induce the wavelength shift. With a relatively low metal thickness up to 6 nm (including 1-5 nm), an assembly of spherical Ag nanoparticles form (Supplementary Figure 2) whose corresponding surface plasmon band is only seen in the visible region (Figure 3c and Supplementary Figure 3a). Supplementary Figure 3b shows such a behavior for Au. In this size range, with increase of the cluster size, a red shift of the position of the transmission minima (and particle plasmon resonance) takes place that is due to the electrodynamic interactions between the particles at a low interparticle spacing. As seen in Supplementary Figure 3a&b, at the particle size range of 6 nm and beyond, this phenomenon is stressed and reflected as a notable broadening of the plasmon band across a long wavelength range. This observation is caused by particles coalescence and the formation of a network structure (H. Takele, H. Greve, C. Pochstein, V. Zaporojtchenko, F. Faupel, *Nanotechnology* **2006***, 17,* Number 14).



Supplementary Figure 3. (a) and (b) Transmission spectra of Ag and Au clusters at different cluster sizes.



Supplementary Figure 4. (a) The p- and (b) s- polarization reflectance of the Au clusters deposited at 500 °C measured at different incidence angles. The polarized specular reflection (*Rp*, *Rs*) reveals a plasmonic response at 600 nm whereas the Brewster dip occurs at the angle of 70° under p-light illumination.



Supplementary Figure 5. SEM image demonstrates the morphology and distribution mode of the Au nanoparticles deposited at 500 °C.