3D Au nanoparticle lattices in MoO_3 for tunable optical and thermo-electrical properties

Senad Isaković,[1,2] Juraj Držić,[3] Ivana Periša,[3] Tihomir Car,[3] Sigrid Bernstorff,[4] Maja Đekić[2] and Maja Mičetić[3]

[1]*University of Zagreb, Faculty of Physics, Bijenička cesta 32, 10000 Zagreb, Croatia*
[2]*Faculty of Science, University of Sarajevo, Zmaja od Bosne 33, 71 000 Sarajevo, Bosnia and Herzegovina*
[3]*Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia*
[4]*Elettra-Sincrotrone Trieste S.C.p.A., Strada Statale 14 km 163.5 in AREA Science Park, 34149 Basovizza/Trieste, Italy*

Incorporating noble-metal nanoparticles into semiconductors offers a powerful means to tailor their functional properties. Here, we demonstrate that embedding ordered three-dimensional lattices of Au nanoparticles (Au NPs) into MoO_3 thin films via magnetron sputtering enables broad tunability of the optical and thermo-electrical behavior. The formation of regular Au NP lattices, with controlled particle sizes, interparticle separations, and ordering, is achieved through precise adjustment of the deposition temperature and layer thickness conditions. Localized surface plasmon resonances (LSPR) arising from Au NPs-and their coupling at small separations-induce a strong modulation of the optical absorption across a wide spectral range. Simultaneously, the film's electrical resistance can be tuned by up to six orders of magnitude, while the activation energy and temperature coefficient of resistance (TCR) are reduced by up to fifty-fold compared to pure MoO_3. These findings offer relevant information for designing oxide–plasmonic hybrid materials, highlighting their potential for next-generation optoelectronic, sensing, and energy-harvesting devices.