PLASMON-ENHANCED VISIBLE LIGHT ABSORPTION FOR PHOTOCATALYTIC WATER SPLITTING

Klaudijus Midveris[1], Tomas Klinavičius[1], Andrius Vasiliauskas[1], Šarūnas Meškinis[1], Muhammad Haris[1], Asta Tamulevičienė[1,2], Tomas Tamulevičius[1,2]

[1]Institute of Materials Science, Kaunas University of Technology, Lithuania
[2]Department of Physics, Kaunas University of Technology, Lithuania
klamid@ktu.lt

One of the most studied methods for producing hydrogen is photoelectrochemical (PEC) water splitting, which uses solar energy and semiconductors that are readily available on Earth [1]. The efficiency of the H_2 evolution process under solar light has been greatly enhanced using heterostructure photocatalysts made of semiconductor materials, coupled with plasmonic noble metal nanoparticles (NPs). This is enabled through the excitations of the conduction band electrons at the metal-dielectric interface. Light may be focused and "folded" onto a thin semiconductor film utilizing fabricated heterojunction structures, enhancing absorption characteristics by generating surface plasmon polaritons (SPPs) propagating at the metal/semiconductor interface as well as localized surface plasmons (LSPs) produced in noble metal nanoparticles [2]. This work investigates the effects of characteristic LSPs in quasi-random distributions of plasmonic metal nanoparticles on the visible light absorption and photocatalytic efficiencies of semiconducting TiO_2 as a vital comparative prerequisite for the utilization of plasmonic NPs organized into ultrathin periodic arrays with photonic spacings, able to support surface lattice resonances (SLRs), that show orders of magnitude stronger localized electromagnetic fields [3].

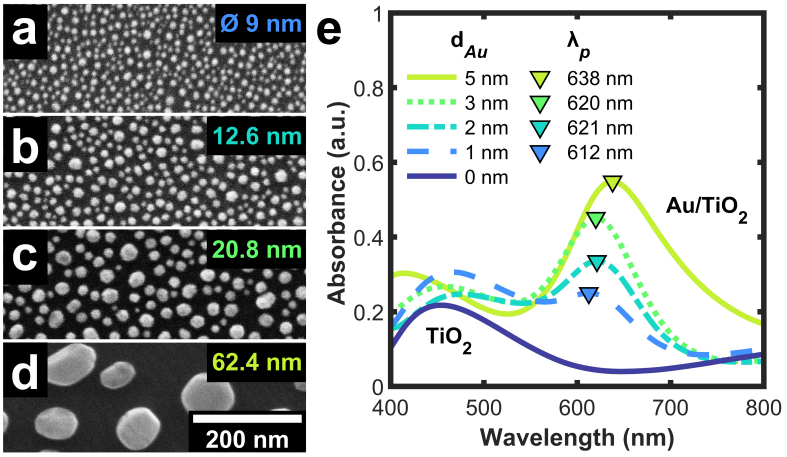

Fig. 1. SEM micrographs of Au nanoparticles (a-d) formed on 160 nm thickness TiO_2 thin film surface (numbers in the top-right corner indicate mean particle diameter) by dewetting different thickness d_{Au} Au films and characteristic LSPR enhanced absorption spectra peaks λ_p of 600 ^{o}C annealed Au-TiO_2 thin films (e).

The work was supported by the Research Council of Lithuania (LMT) project No. S-MIP-23-93.

[1] ZHOU, Peng, NAVID, Ishtiaque Ahmed, MA, Yongjin XIAO, Yixin, WANG, Ping, YE, Zhengwei, ZHOU, Baowen, SUN, Kai and MI, Zetian. Solar-to-hydrogen efficiency of more than 9 percent in photocatalytic water splitting. Nature 2023.
[2] ATWATER, HA, MATERIALS, A Polman. Plasmonics for improved photovoltaic devices. Nature 2010.
[3] JUODĖNAS, Mindaugas, TAMULEVIČIUS, Tomas, HENZIE, Joel, ERTS, Donats and TAMULEVIČIUS, Sigitas. Surface Lattice Resonances in Self-Assembled Arrays of Monodisperse Ag Cuboctahedra. ACS Nano 2019.