

Tuning of H₂ production by surface enlargement of TiO₂ based photocatalysts decorated with Au and Pd nanoparticles

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The development of an efficient photocatalyst capable of producing enough hydrogen for applications in everyday life under direct sunlight exposure is still challenging. Among a large choice of proposed materials, TiO₂-based materials remain the most suitable catalysts for industrial applications due to its performance, easy accessibility and low price of TiO₂.¹⁻² In this work, a new concept for enlarged surface microstructured TiO₂ photocatalysts for H₂ production by direct water splitting is proposed. The study starts with the theoretical design and analysis of different three-dimensional models (3D) by considering the technological restrictions. Next, a micromachining process based on deep-reactive ion etching (DRIE) is optimized to obtain a robust and repeatable pattern on silicon –that serves as substrate– for the subsequent deposition of TiO₂ thin films by physical vapor deposition (Fig. 1a). Au and Pd plasmonic nanoparticles (NPs) are deposited on the 3D photocatalysts by chemical photodeposition and atomic layer deposition (ALD), respectively. The study of the 3D TiO₂-based photocatalysts was carried by XRD, XPS and UV/Vis spectroscopy. The influence of the area enlargement factor (AEF) on the morphology and quality of the enlarged surface was thoroughly analyzed by SEM and cyclic voltammetry, and finally correlated to the catalytic performance of H₂ production under UV/Visible irradiation in terms of the AEF and the TiO₂ film thickness. It was demonstrated that by augmenting the surface area by a factor of 3, the H₂ production is enhanced by a factor of 13. Moreover, the impact of the Au and Pd NPs morphology and optical properties reached a supplementary 4 and 16-factor H₂ production rate enhancement (Fig. 1b-c), respectively; proving the superior conformality and controlled deposition of ALD over chemical photodeposition for NPs growth. The advantages and development of robust and hierarchical photocatalysts using microelectromechanical fabrication techniques are hence highlighted as potential solutions for a broad range of applications from photocatalysis, electronics, and sensing elements to 3D metamaterials.

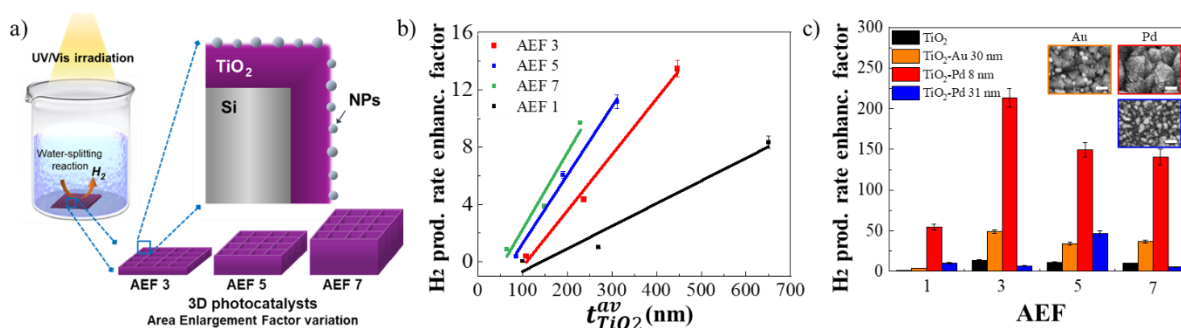


Figure 1. (a) Conceptual scheme of microstructured TiO₂-based photocatalysts with variant AEF. H₂ production rate enhancement for variant AEF: (b) as a function of the TiO₂ average thickness, and (c) for TiO₂/Au and /Pd NPs photocatalysts, inset: SEM images of NPs on the TiO₂ (scale 100 nm).

1. Mendoza-Diaz, M. I. *et al. J. Phys. Chem. C* **124**, 25421–25430 (2020).
2. Mendoza-Diaz, M.-I. *et al. Appl. Surf. Sci.* **588**, 152919 (2022).