VIII International School and Conference on Photonics - PHOTONICA2021

Influencing on optical properties of buffered TiO_2-Au thin film systems by deposition and annealing parameters

N. Milicevic, M. Novakovic, J. Potocnik, L. Rakocevic, M. Milovic, N. Abazovic and D. Pjevic

Vinca Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia

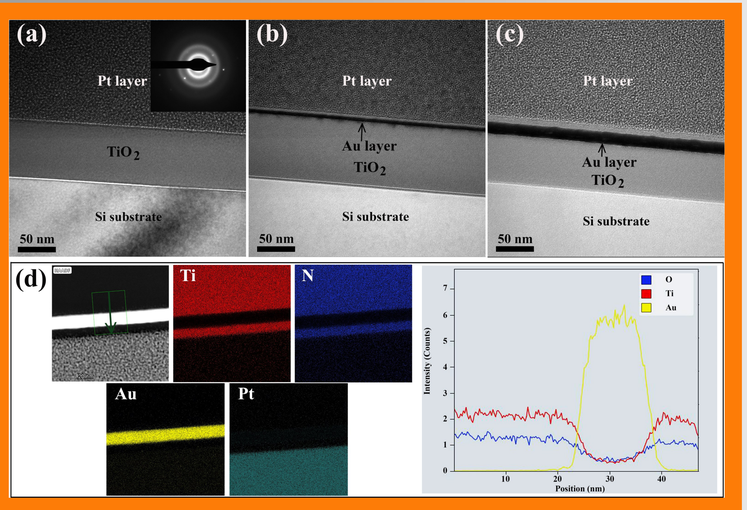

Fig. 1. Low magnification cross-sectional TEM bright-field micrographs of pure TiO_2 thin film with corresponding electron diffraction pattern in the inset (a) and TiO_2 systems with Au buffer layers thicknesses of 5 nm (b) and 15 nm (c), also presenting Si substrate and Pt protective layers at the top of the samples.
(d) STEM-HAADF image of TiO_2-Au sample with the 15 nm thick buffer layer with corresponding EDS maps highlighting the Ti, O, Au and Pt elements (left side) and elemental line profiles taken along the green line as indicated in HAADF image (right side).

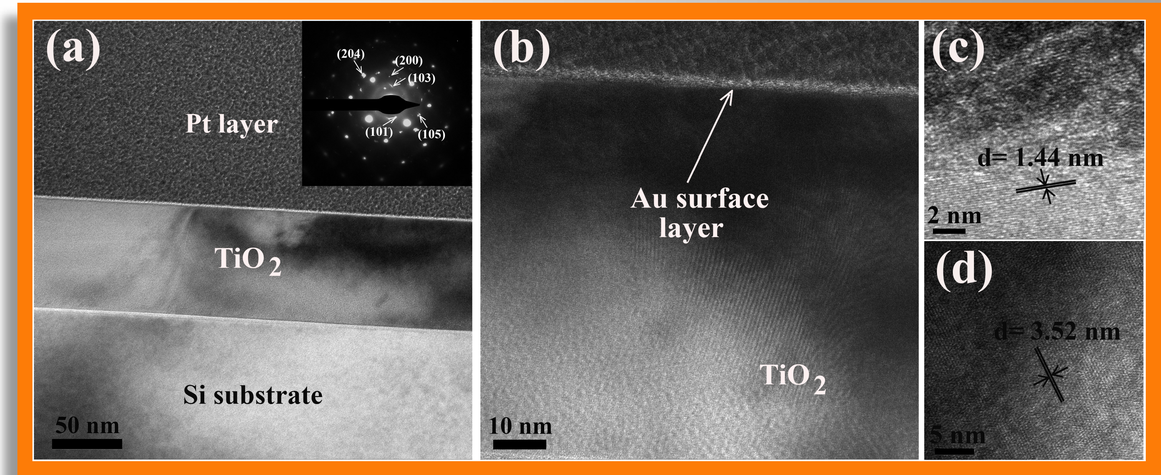

Fig. 2. TEM analysis of TiO_2-Au sample with the 15 nm thick buffer layer, after annealing for 3 hours at 400 °C: (a) low magnification bright-field TEM micrograph of the sample presenting TiO_2 layer, Si substrate and Pt protective layer, with SAED pattern given in the inset; (b) high magnification bright-field TEM micrograph of the near-surface region showing a clearly visible interface layer at the sample surface; (c) and (d) HRTEM micrographs of the surface layer and TiO_2 layer, respectively, with the measured d-spacings.

INTRODUCTION

TiO_2 and TiO_2:Au thin films were obtained by DC magnetron sputtering of Ti target with Ar ions in O_2 atmosphere. Three different systems were deposited for comparison, with different thickness of buffered Au layer. Post deposition annealing for 3h on 400 °C was carried out in nitrogen atmosphere. For structural analyses XRD, XPS, TEM and SEM methods were used, while for optical characterization UV/Vis method was used. The photo-degradation rate was measured using Rhodamine B which simulated pollutant. Post deposition annealing caused diffusion of Au atoms through the layer toward the surface. Structural characterization showed that deposited films have good stoichiometry of TiO_2 in anatase phase and that concentration of Au on the surface can be controlled by sputtering and annealing conditions. By controlling Au concentration on the surface, we can influence on optical properties of deposited TiO_2 thin films.

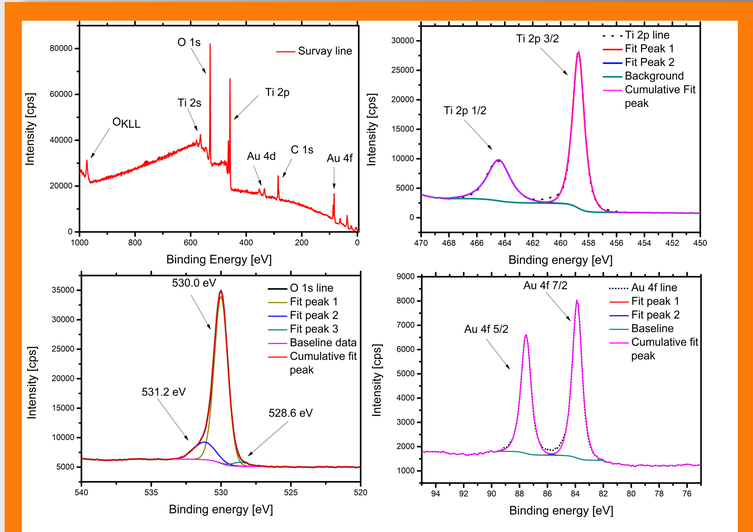

Fig. 5. XPS analysis of TiO_2-Au 15 sample: (a) survey spectrum; (b) Ti $2p_{3/2}$ and $2p_{1/2}$ lines; (c) O_{1s} line and (d) Au $4f_{5/2}$ and $4f_{7/2}$ lines.

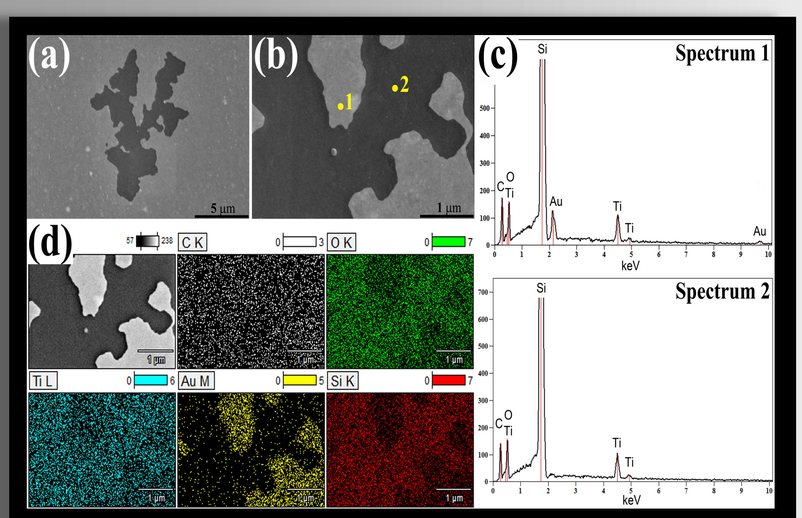

Fig. 3. FESEM-EDS characterization of TiO_2-Au 15 AN sample surface: (a) and (b) micrographs recorded at different magnifications (10 000 and 50 000 time, respectively); (c) EDS spectra obtained at two different points indicated with yellow dots in image b; (d) corresponding elemental mapping from the whole area shown in FESEM image.

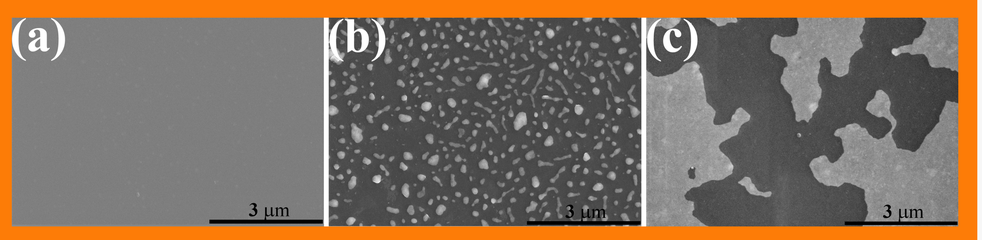

Fig. 4. FESEM topography micrographs of (a) as-deposited TiO_2 thin film and annealed buffered TiO_2-Au system with: (b) 5 nm and (c) 15 nm thick Au layer.

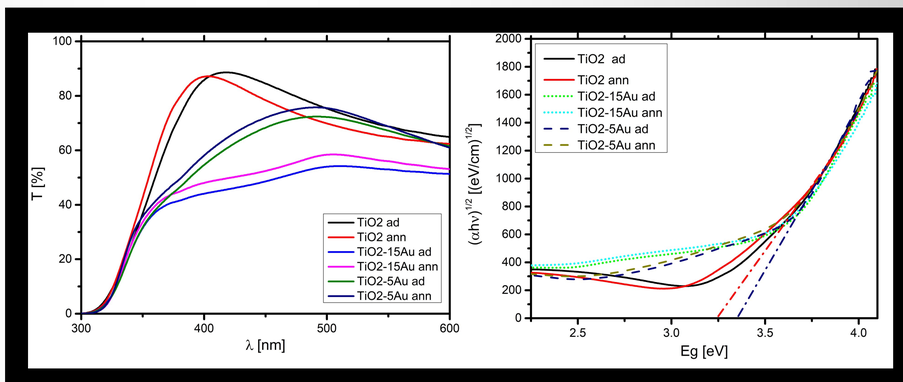

Fig. 6. Transmittance spectra for deposited TiO_2 and TiO_2-Au thin films and Tauc's plot for determination of energy gap values.

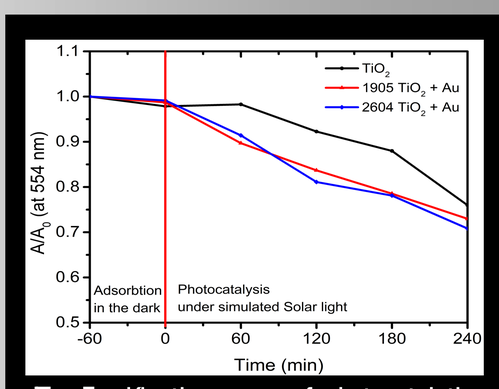

Fig. 7. Kinetic curves of photocatalytic degradation of Rhodamine B on TiO_2 and TiO_2-Au samples.

CONCLUSION

* Au buffered TiO_2 thin films were successfully produced by DC sputtering method with Au layers of different thickness placed 5 nm and 10 nm below top TiO_2 layer.
* Annealing of thin films induced migration and diffusion of Au atoms into the layer and toward the surface.
* By controlling sputtering deposition parameters, annealing temperature and time of annealing we can produce TiO_2 thin films with desired concentration of Au on the surface, changing its optical properties.
* Photocatalytic properties of TiO_2-Au thin films were improved compared to pure TiO_2.
* Samples that were subject to additional thermal treatment in a nitrogen atmosphere reduced the values of the contact angle towards both water and organic liquid.

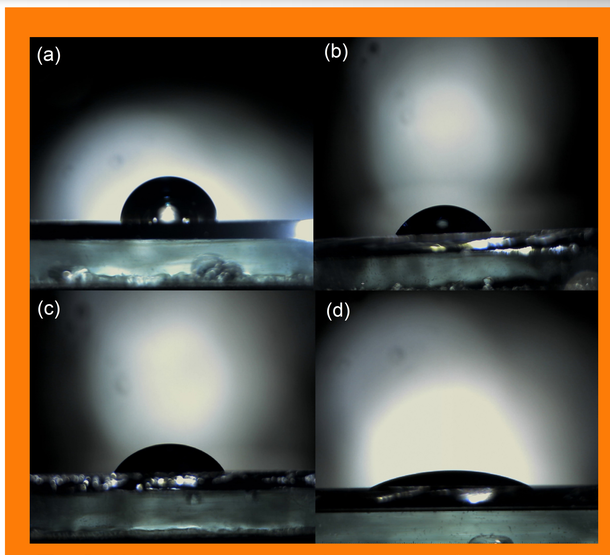

Fig. 8. Side view photographs of water (a and b) and diiodomethane (c and d) droplets on the surface of TiO_2 and TiO_2-Au 5 samples, before and after annealing, respectively.