European Physical Society
Condensed Matter Division

Nanoribbon arrays of palladium nanoparticles on flexible substrates for transparent conduction and hydrogen detection

Elena H. Sánchez[1, 2], Peter S. Normile[2], Jose A. De Toro[2], Rubén Caballero[1], Esther Rebollar[3], Marta Castillejo[3], Jose M. Colino[1]

[1] Instituto de Nanociencia, Nanotecnología y Materiales Moleculares and Depto. de Física Aplicada, Universidad de Castilla-La Mancha, Campus de la Fábrica de Armas, 45071 Toledo, Spain
[2] Instituto Regional Investigación Científica Aplicada and Depto. de Física Aplicada, Universidad de Castilla-La Mancha, 13071 Ciudad Real, Spain
[3] Instituto de Química-Física Rocasolano, Consejo Superior de Investigaciones Científicas, Serrano 119, 28006 Madrid, Spain

Elena.HSanchez@uclm.es

A multifunctional material system consisting of nanoribbon arrays of palladium nanoparticles (NPs) prepared by a two-stage nanostructuring process is presented. The first stage involves irradiation of polyethylene terephthalate (PET) substrates with linearly-polarized 266 nm-wavelength laser light to obtain laser-induced periodic surface structures (LIPPS) [1] (nanoripple patterns of 204 nm mean lateral spacing and 46 nm average amplitude – see Fig. 1a) of high coherence over a large substrate area. The second stage comprises oblique deposition of Pd nanoparticles (of 5 nm mean diameter) from a sputter gas phase aggregation source, where LIPSS act as self-shadowing templates of the obliquely-incident (at angles, 60 ≤ ≤ 75º to the PET substrate normal – see Fig 1b) NP beam. The resulting arrays of NP ribbons (of around 20 nm thickness) formed on the ripple ridges possess mean ribbon widths that correlate (negatively, as expected) with the NP beam deposition incidence angle (). Analysis of the optical transmittance (in the visible and near-UV ranges) and four-probe electrical resistance (at room temperature) suggests our "Pd nanoribbon arrays on PET" material system as a candidate for anisotropic and flexible transparent conductor. An additional hydrogen-sensing functionality is demonstrated by observing reversible detection of hydrogen with good electrical sensitivity in the dilute regime [2].

References

[1] E. Rebollar et al., *Eur. Polym. J.*, **73** 162-174 (2015).
[2] E. H. Sánchez et al., *Appl. Surf. Sci.*, **470** 212-218 (2019).

Figure 1. (a) AFM topographic image (5 5 μm^2 size) of patterned PET substrate. The inset is a Fast Fourier Transform of the image. (b) Schematic of nanoscale LIPSS and nanoribbon formation by oblique deposition. The angle of incidence (θ) is defined with respect to the normal to the *average* substrate surface. (c) HR-SEM image of Pd nanoribbon arrays deposited at θ = 65°.