Plasmonic nanostructures based hot-electron Si photodetector

Dana Cristea, Roxana Tomescu, Adrian Dinescu

National Institute for Research and Development in Microtechnologies- IMT Bucharest, 126A Erou Iancu Nicolae, 077190 Voluntari, Ilfov, Romania

dana.cristea@imt.ro

Hot electrons produced from the decay of localized surface plasmons in metallic nanoparticles have been studied in the last year for applications in photodetection and photocatalysis [1]. Hot electron devices consist typically of a metal surface in contact with a semiconductor forming a Schottky barrier [1, 2] and operate based on internal photoemission process (IPE). IPE enables sub-bandgap photodetection making thus silicon devices suitable for operation in NIR-SWIR range.
The paper presents an improved architecture for Au/n-Si Schotky photodetector with plasmonic NPs with high responsivity in the range 1300-1550 nm. To allow incident light to be momentum matched and efficiently coupled to SPs we used nanostructured Ag or Au layers. We developed a simple process for the fabrication of plasmonic nanostructures without using costly and time-consuming nano-lithographic processes. The process is based on vacuum deposition of very thin Ag or Au layer followed by thermal annealing. A periodic structure composed of flattened nano-hemispheres is obtained (fig. 1). The diameter and of the nanostructures depends on the initial thickness of the metal layer and the annealing and can be tuned over a large range (2-2000 nm). The nanostructured layer acts as metamaterial absorber [2] that improves the efficiency of hot electrons generation. The responsivity was further improved by coupling Ag or Au nanoplasmonic nanoparticles with grating-like electrodes. The device spectral characteristics can be tuned by modifying the geometry of the metamaterial.
The experimental devices show very high responsivities, up to 12 mA/W at 1550 nm, and 30 mA/W at 1310 nm @ 5V applied bias, among the highest reported [3].

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References

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[2] C. Ng, J. J. Cadusch, S. Dligatch, A. Roberts, T. J. Davis, P.Mulvaney, D. E. Gómez, ACS Nano 2016, 10, 4704–4711.
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Figures

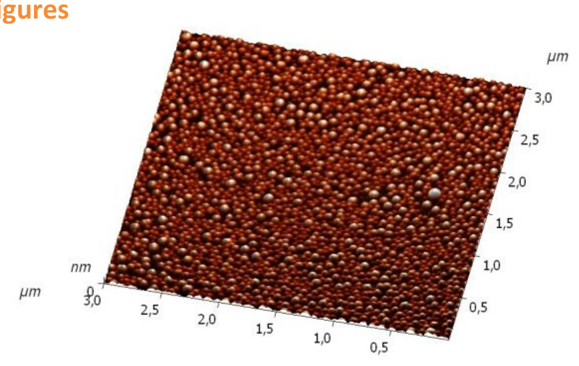

Figure 1. AFM image of Ag NPs obtained by thermal annealing (250 °C, 5') of a150 nm thick Ag layer.

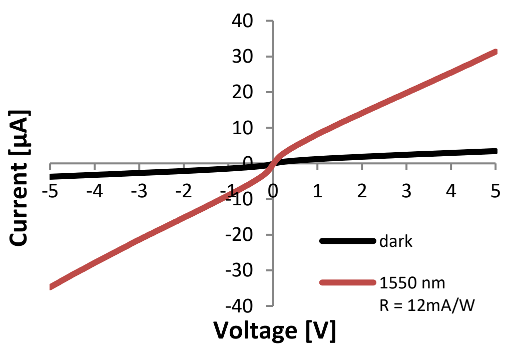

Figure 2. I-V characteristics in dark and under illumination for a Schottky Si device with Au interdigitated electrodes and Ag NPs (ϕ=30 nm).