Seebeck nanoantennas and self-switching diode nanorectifiers for energy harvesting applications

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Nanoantennas are metallic resonant structures at the core of new advances in photonics due to their ability to manipulate and confine the free-propagating optical energy into a sub-wavelength scale with a high accuracy level of control. These types of resonant structures work by inducing along its volume a high-frequency alternate current that can subsequently be used to sense or recover the trapped energy; showing its enormous potential in the field of electromagnetic energy [1].

Direct rectification of the alternate current (optical rectification) is the straightforward manner to recover from antennas the optical energy into DC power. This task is commonly achieved by coupling to the gap of nano-antennas fast nanorectifiers able to operate at optical frequencies. These so-called rectifying nanoantennas seem to have great potential in the field of energy harvesting sine they exhibit a high theoretical conversion efficiency (claimed to be 100%).

Notwithstanding, current rectifying nanoantennas do not reach the limit of efficiency because of the employed rectifiers. Must explored nowadays rectifiers are based on metal-insulator-metal and metal-insulator-insulator tunnel barriers that exhibit a poor diode-like behavior and high interface resistivity, leading to an inefficient energy transfer between both elements. In order to use nanoantennas as electromagnetic energy harvesting devices other mechanism or strategies must then be explored [2].

In this work, two types of optical devices are presented aimed to recover the electromagnetic energy contained in the terahertz regime (THz) of the electromagnetic spectra. The first devices are referred as Seebeck nanoantennas, these type structures combine the optical properties of the antennas in order to sense the THz radiation with the Seeebeck effect as a transduction mechanism. The particular strategy permits to overcome the unmismatch problem currently exhibit by rectifying nanoantennas [3]. The second device use as strategy the geometrical rectification presented in the so-called self-switching diode [4]. These devices are incorporated as fast rectifiers and coupled to the nanoantennas in order to obtain DC signals. The optical-to-electrical conversion efficiency of both devices is evaluated by performing numerical simulations on COMSOL-Multyphysics and SILVACO software packages. The advantages and drawbacks of both type of devices is discussed along the manuscript, unveiling its potential as devices for harvesting applications.

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