Three-Dimensional Metallic Networks – 'Nano Netals'

Adi Salomon
Department of chemistry, institution of nanotechnology
Bar-Ilan University, Israel

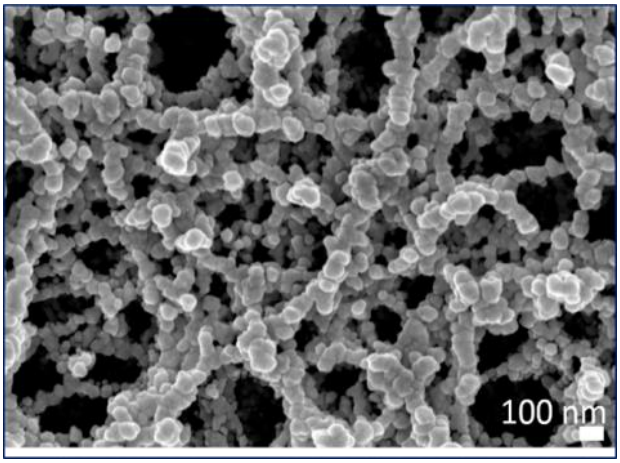
Metallic nano-structures are well-known to exhibit unique optical properties. It is attributed to excitation of surface plasmons (SPs), coherent oscillations of the metal's free electrons, which lead confinement of the electromagnetic (EM) field at their vicinity. The geometrical parameters of the metallic nano-structures (particles or cavities) determine their EM enhancement and confinement at specific frequencies. It is appealing to think about a universal plasmonic device, in which a rainbow of plasmonic modes at different frequencies will be excited at different areas and will harness the EM field. Furthermore, one would like to translate their unique optical phenomena they carry into a large-scale and by that extend their potential application. However, even nowadays technological endeavors cannot be answered by state-of-the-art nanofabrication routes, because it demands fine structures at the nano scale over a large scale piece. Moreover, nanoporous metals are artificial and therefore, their properties are a direct result of the preparation strategy. Practically, all the current techniques are multi-step and the resulted porous metal contains additive materials which eventually govern their optoelectronic properties and may deteriorate their performance.

We introduce a large-scale piece of metal with a nanoscale architecture of a three-dimensional (3D) continues network with unique optical properties. The network is made of interconnected metallic nano-sized ligaments of about 50nm and connective percolating (open-cell) nano-pores. The pores are bimodal in size, ranging from few nanometers to a few hundred nanometers. The large size of the pores enables permeability of a guest material, whereas the small size pores are essential for photo-catalytic reactions. Furthermore, the metallic nanoparticles and ligaments are connected directly giving rise to high conductivity. The resulted network has a distinct color,

different from the bulk, which is dependent on the metal type and on the network film thickness. It has relatively high non-linear response (Second Harmonic Generation) and show indication for hot carrier generation and for photo-catalytic activity.

The idea is to use such a metallic network simultaneously as panchromatic light absorbers and as photo-catalysts capable of absorbing a large fraction of the solar spectrum by plasmonic excitation. The plasmons decaying should lead to generation of energetic carriers that are used to carry out useful chemical transformations or chemical reactions.

Several metallic and metal-oxide networks have been fabricated among them Cu, Ag, Au, Al, Pt, Ti and TiO_2. We characterize the unique opto-electronic properties of such metallic nano-architecture networks, which are named ‘Netals’.



SEM of our 3D Silver Network