3D metallic networks - A new class of materials

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Bilbao 2018
Motivation: Light Matter Interaction @Nano Scale

- Hybrid photonic materials
- Photochemistry/ photo-catalysis
- Long Rang Energy transfer
- Strong coupling / C-dots


Well defined Metallic Nano Structures

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Confinement of light onto a flat surface/interface


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But...

* In corals light is diffusively scattered enabling symbiotic algae to capture a large fraction of photons and optimize subaquatic photosynthetic energy production.
3D Metallic Network (NetAL)

Large scale 3D Metallic electrode / huge surface area

Ron, R. et al. Advanced Materials 2017

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Why?

- Very high surface area - Catalysis/ photo-catalysis
- Light transparent metal
- Metamaterials
- Electrodes for batteries
- Both localized and propagating surface Plasmons
- Optical sensing, photovoltaics, LEDs, nonlinear optics, thermo-electrics, field-emission.
- Scalable
Strategies for preparation of large-scale disordered nanoporous metals

Ron, R. Haleva, E. and Salomon A. Advanced Materials 2018 (progress Review, accepted)

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3D Metallic network

Multisizes of holes and particles – large pores for molecular transport

Ron, R. Gachet, D. Racav K. and Salomon A. *Advanced Materials* 2017, 29, 1604018
3D Metallic Network

Small tips

500 nm

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How does it work?

PVD On Different substrates

Controlling the building blocks size

Effect of surface chemistry on the network growth
Controlling the building blocks size

Ron, R. Haleva E. and Salomon, A.  *Growth mechanism of 3D metallic network using PVD (under preparation)*
Metallic networks as **Color Generators**

Light: Science & Applications (2017) 6, e16233; doi:10.1038/lsa.2016.233

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Modulation of the Refractive Index at the submicron scale

Henning Galinski, Gael Favraud, Hao Dong, Juan S Totero Gongora, Grégory Favaro, Max Döbeli, Ralph Spolenak, Andrea Fratalocchi, and Federico Capasso  Light: Science & Applications 2017
Extraordinary Transmission: excitation of surface plasmons and directed scattering

Ron, R. Haleva, E. and Salomon A. Advanced Materials 2018 (progress Review, accepted)
Cathodoluminescence Imaging and spectroscopic measurements

* Multipole plasmonic modes

* Ron, R. et al. under preparation
Cathodoluminescence Imaging and spectroscopic measurements

* Ron, R. et al. under preparation
Applications
PEC today – challenges

NanoPorous Metallic networks
Surface enhance Raman scattering as a probe for photo-catalysis

Reduction of $C_{60}$ fullerenes on an Ag NETAL (metallic network)

Electron transfer from the metallic electrode into $C_{60}$ molecules

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Photo-Catalysis
By formation of energetic carriers
Second Harmonic Generation measurements

Huge Non Linear responses (particles and holes)
Non Linear Responses

Frequency dependency

- Each wavelength results as different area of 'hot spots'

Ron, R. Nature: Light, Science & Applications, 2018, under second revision
Summary

- Scalable and robust nanoporous metallic network
- Colors generator
- Nonlinear optical properties
- Catalysis/Photo-catalysis
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Thank You!

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