Bottom-up plasmonic metasurfaces: Macroscopic thermal management, thin-film photovoltaics and control of the interband absorption

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Abstract

In numerous applications of light transformation into heat the focus recently shifted towards highly absorptive materials featuring nanoplasmons. It is currently established that noble metals-based absorptive plasmonic platforms deliver significant light-capturing capability and can be viewed as super-absorbers of optical radiation. However, direct experimental evidence of plasmon-enabled *macroscopic* temperature increase that would result from these efficient absorptive properties is lacking so far. I will present a general quantitative method of characterizing light-capturing properties of a given heat-generating absorptive layer by macroscopic thermal imaging. We monitor macroscopic areas that are homogeneously heated by several degrees with plasmonic nanostructures that occupy a mere 8% of the entire surface, evidencing significant heat generation capability of nanoplasmon-enabled light capture and its direct applicability in thermophotovoltaics and other applications.

As a second example, I will discuss the engineering of front and back plasmonic electrodes and reflectors for thin-film photovoltaic technology. Particular applications are organic [1], crystalline [2] and amorphous thin-film solar cells.

Finally, I will present the concept of 'interband nanoplasmonics'. Plasmonic metals like gold and silver show two distinct regions in their dielectric functions, one with dominant free electron contribution and one with dominant bound electron contribution. The former can be explained by Drude term while Lorentzian oscillator describes the latter. Certain metals also exhibit spectrally well-defined interband transitions – examples are Al (1.5eV), Cu (2.1eV), Fe (2.5eV) or Ni (4.7eV). We examine the interaction between the free and bound electrons and show both theoretically and experimentally that the optical response, related to the interband transition, is remarkably affected by the presence of localized plasmon resonance. We see stark modification of the absorption, associated with the interband transition, while we by design spectrally approach plasmon resonance to the IB transition to steer their coupling. We foresee that these effects can be used to understand the fundamentals and control the optical response of the transition metals, and might find exciting applications in catalysis and photovoltaics.

References

[1] B. Niesen et al., Adv. Energy Mater. **2**, 145 (2013)
[2] O. El Daif et al., Sol. Ener. Mat. Sol. C **104**, 58 (2012).