Resonant Absorption Phenomena in Metals: How to make good use of optical losses?

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Nanostructured metals received significant amount of attention in recent years due to exciting plasmonic and photonic properties such as strong-field localization, light concentration, and strong absorption and scattering at the localized or delocalized surface plasmon resonance frequencies. In particular, resonant absorption phenomena in plasmonic nanostructures is widely studied for applications in photothermal therapy, thermophotovoltaics, heat assisted magnetic recording, hot-electron collection, and biosensing. Here, we discuss two different approaches for obtaining narrow-band resonant absorption filters at visible wavelengths. First structure is based on the surface lattice resonances in periodic nanowire and nanoring arrays fabricated on a reflecting metallic substrate (See Fig. 1a). In experiments, we observe very sharp absorption resonance peaks with 12 nm bandwidth with over 90% total absorbance in visible frequencies. Simulated absorption bandwidths are as narrow as 5 nm. The resonance absorption wavelength, amplitude of the absorption peak and the bandwidth can be controlled by tuning the period of NBA arrays (Fig. 1b), as well as the metal thickness and grating width. The radiative losses are significantly reduced in our design enabling an ultra-sharp resonance peak.

As a second approach, we studied the strong interference effects in unstructured continuous metal-insulator-metal filters. By arranging the metal thickness carefully, we show that one can obtain almost perfect absorption in continuous metal films. The dielectric spacer thickness controls the interference wavelengths, whereas the metal thickness control the amplitude and the bandwidth of the filters. We will also briefly discuss our current results on narrow-band transmission filters based on the strong interference effect. Designing optical absorption and transmission filters is a promising route that could find use in narrow-band thermal emitters in thermophotovoltaics, ultra-sensitive plasmonic biosensors, and detectors.

Figure 1. a. Metal nanodisks on continuous metal substrate. b. Absorption spectra as a function of wavelength and nanodisk array period. The resonance wavelength scales with the periodicity.