Total resonant absorption of light by plasmons in periodic metallic nanoporous film

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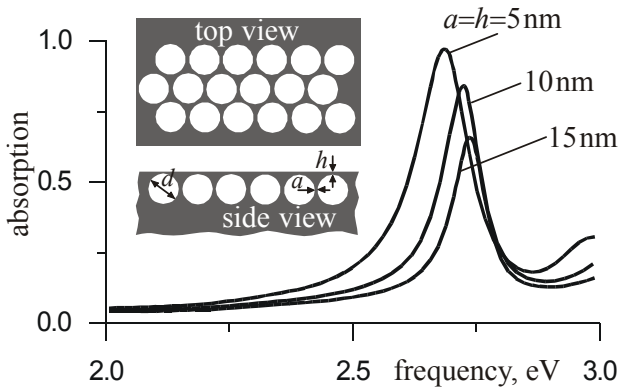
Recently, [1] plasmon excitations in gold films with periodically arranged nanovoids have been experimentally observed and their remarkable photonic properties established. It was presumed in [1] that plasmon modes excited in spherical nanocavities couple much more effectively to light than those in metallic spheres, since they localise the electromagnetic field into the small volume, which results in strong reflectivity resonances observed in experiment. On the other hand, the optical properties of plasmons in spherical metallic objects having surfaces with negative curvature (i.e. the inner surface of metallic shell) can be effectively tuned over a wide range by nano-engineering the size parameters [2,3].

In this paper, we consider a two-dimensional layer of periodically arranged voids buried into the metallic substrate (see inset in figure). We have calculated the absorption spectra of such a structure in the scattering matrix approach with making use of re-expansion of the plane-wave representation of electromagnetic fields in terms of spherical-waves [4]. Figure shows the resonant absorption spectra of light incident normally onto a nanoporous silver film for different structure parameters: the intervoid spacing a and void-layer deepening h. It is seen that the almost total resonant light absorption (the effect of "black metal") emerges in visible when the intervoid spacing a and void-layer deepening h are thin enough in comparison with skin depth, which provides a strong coupling of void plasmons with light. The frequency of the resonance can be easily tuned by changing the geometric parameters of the structure. The strongest resonant absorption can be achieved for the structure with d=310 nm and a, h<5 nm. The total resonant light absorption is associated with giant local field enhancement in such a structure.



We conclude that a metallic nanoporous films represents a unique structure, which demonstrate black metal effect in visible and whose absorption and local-field properties can be effectively tuned over a wide range by nano-engineering the pore and periodicity dimensions. This makes this structure very attractive for various applications in future submicron light technology.

References

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