Wide band transparent metallo-dielectric nanowires at telecommunications wavelengths: more transparent than glass

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Hiding objects has been object of strong research efforts since the pioneering works on cloaking structures [1] at the beginning of this century. A typical cloaking structure present several cons for its practical realization at visible and near infrared (IR) wavelengths. In particular, the complex building blocks represent a challenging nano-fabrication problem. The available materials lead to relatively large absorption levels in the structures which can preclude or severely limit the desired performance of a practical device. Also, the working bandwidth is typically quite narrow. On the pros side, we have structures that really hide objects to electromagnetic interaction.

If we lower the requirements of fully canceling the electromagnetic interaction with a given object, but still we need low scattering, several approaches can come into play. For instance truly invisibility can be achieved for simple geometries and absorptionless materials as theoretically demonstrated decades ago [2]. Despite its simplicity, the approach of obtaining near zero scattering cross section for given body presents a problem. Namely, the object can not hide other objects placed in its interior.

If scattering at certain angles, for instance backscattering, is the magnitude to be minimized, several approaches can be taken. Probably the simplest one take advantage of the coherent excitation of electric and magnetic dipoles in the object in such a way that zero backward or almost zero forward scattering can be achieved [3].

If the goal is achieving transparency for a given metallic object with known geometry, a relatively simple while effective approach is cover or load the object with a suitable dielectric, as demonstrated with spherical [4] or cylindrical [5,6] objects. This approach is the so called plasmonic cloaking.

In this work [7] we propose and characterize plasmonic cloaks to hide electrical interconnects to near IR radiation in bands used in telecommunications.

we analyze in detail the conditions required to obtain small scattering efficiency in a core-shell cylinder for any metal or dielectric combination in the infrared at bands relevant to telecommunications. By the use of a simple model based on the quasi-static approximation with radiative corrections to the polarizability of a core-shell cylinder, we obtain general properties required to achieve transparency in realistic structures. We also check our predictions against a more accurate model based on Mie theory for cylinders.

We find that, under rather general conditions, metal nanowires with high refractive index coating can show a transparency region which is more robust against fabrication defects (size polydispersity) than metal coated fibers. Also, it is shown that it is possible to obtain up to three orders of magnitude lower scattering efficiency , compared with raw metal cylinders, in a band as wide as 20% of the central frequency, and with realistic materials (Si coated Ag wires) in the infrared. The transparency condition is robust regarding the angle of incidence and polarization.

It is shown that the near field scattering is extremely weak in the transparency region. Hence, the coupling through evanescent modes among equal cylinders is essentially negligible. Then, a high density assembly of appropriately designed nanowires present a extremely low scattering efficiency. Even the wavefronts are negligibly disturbed in a random and high density assembly of transparent nanowires.

This system is hence a suitable building block for electrical wiring where keeping optical transparency is mandatory.

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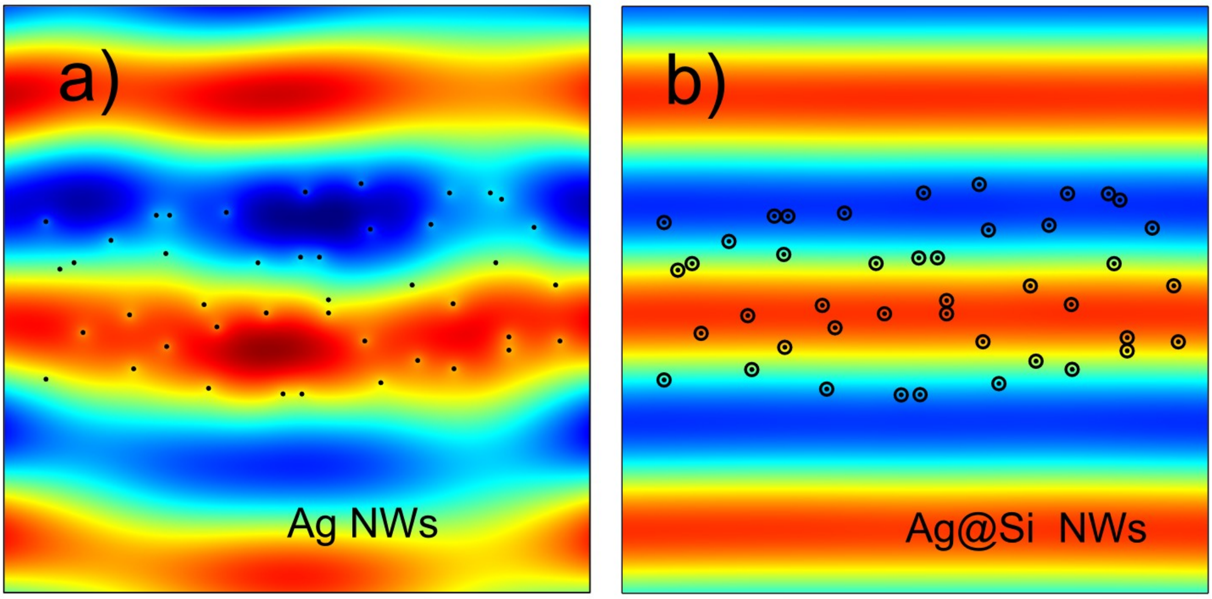
Figures.



(a) Map of the electric field along the cylinder axis direction at a wavelength of λ = 1550 nm for TM polarized waves for an ensemble of bare Ag NWs (R = 13.6 nm) distributed randomly within a slab. (b) Electric field map (Media 2) corresponding to the the same arrangement of (a). The scattering units in this case are Ag@Si core-shell NWs (Rc = 13.6 nm, Rs = 45nm) .