DIPARTIMENTO DI SCIENZE MATEMATICHE E INFORMATICHE, SCIENZE FISICHE E SCIENZE DELLA TERRA
Dottorato di Ricerca in Fisica

Appunti di Fisica '22

9 marzo ore 15:30

su Microsoft Teams "Seminari di Appunti di Fisica"

Deeply Subwavelength Layered Metamaterials: From Hyperbolic Dispersion Metasurfaces to Fano Resonance Optical Coatings

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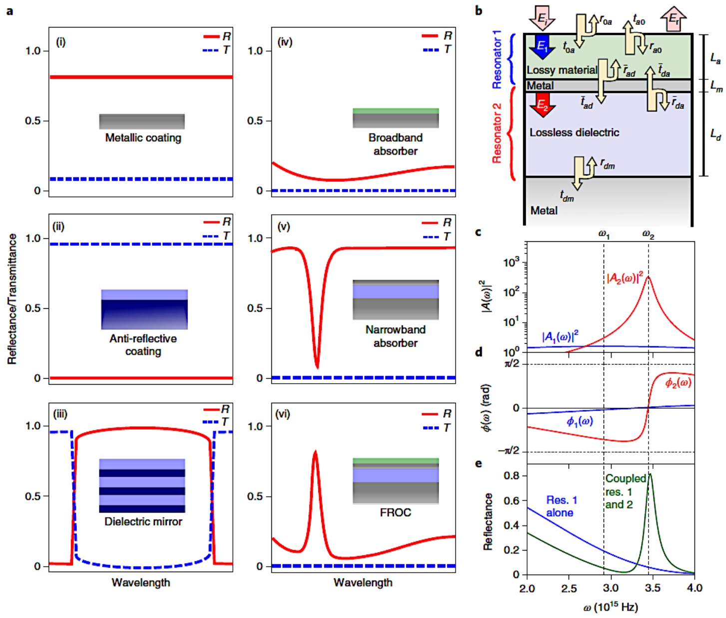
In recent years a wide interest has been spurred by the inverse design of artificial layered heterostructures for nano-biophotonic applications. In particular, the extreme optical properties of artificial hyperbolic dispersion nanomaterials allowed to access new physical effects and mechanisms. The unbound isofrequency surfaces of hyperbolic metamaterials and metasurfaces allow to access virtually infinite photonic density of states, ultrahigh confinement of electromagnetic fields and anomalous wave propagation. Similarly, by layering metal-dielectric thin films is possible to obtain a type of optical coatings that exhibit photonic Fano resonance, or a Fano-resonant optical coating (FROC). We expand the coupled mechanical oscillator description of Fano resonance to thin-film nanocavities. We observed that semi-transparent FROCs can transmit and reflect the same color as a beam splitter filter, a property that cannot be realized through conventional optical coatings. Here, we present the physics of different deeply subwavelength layered heterostructures and how they allow to control light-matter interaction at the single nanometer scale, including within living systems.



Fano resonance in thin-film optical coatings. **a,** Schematics of the reflectance R and transmittance T of the main types of optical coatings, including metallic coatings used as mirrors and beam splitters (i), anti-reflective dielectric coatings (ii), dielectric (Bragg) mirrors (iii), broadband optical absorbers (iv), narrowband absorbers (v) and the proposed FROC coating (vi). **b,** Schematic of the structure of a FROC consisting of two weakly coupled resonators where resonator 1 (the top two layers consisting of lossy material and metal) represents a broadband absorber and resonator 2 (layers 2 to 4 consisting of metal, dielectric and metal) represents a narrowband absorber. The two resonators share a metal layer that determines their coupling strength.

References

[1] K. V. Sreekanth, Antonio De Luca & Giuseppe Strangi "Experimental demonstration of surface and bulk plasmon polaritons in hypergratings" **Scientific Reports 3,** 03291 (2013)

[2] K. V. Sreekanth, Y. Alapan, M. ElKabbash, U. A. Gurkan, E. Ilker, M. Hinczevski, A. De Luca and G. Strangi **Nature Materials 15, 4** 4609 (2016)

[3] ElKabbash, M., Letsou, T., Jalil, S.A. Hoffman N., Lininger A., Hinczewski M. et.al & G. Strangi. "Fano-resonant ultrathin film optical coatings". **Nature Nanotechnology** (2021). https://doi.org/10.1038/s41565-020-00841-9