Thin-film, wide-angle, design-tunable, selective perfect absorber from near UV to far infrared

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Materials and methods

- Sequential e-beam evaporation on Si wafer
  1. 10nm -Cr
  2. 150nm -Au
  3. 10nm -Cr
  4. SiO₂

- Photolithography
- Au deposition by DC sputtering
- Metal lift off by acetone for periodic squares/ Annealing

Optically thin films to form gold nano-islands

- Samples for absorption in (a) mid-IR and (b) far-IR region
  - Reflectivity spectra showing strong absorption up to 99%

- Samples for broad-band absorption in (a) UV (b) Near IR
  - Reflectivity spectra for sample in far IR as a function of thickness of (a) SiO₂, (b) top gold square. Optimum thickness of SiO₂ and top gold square are necessary for perfect absorption to occur.

Theory

- Electric dipole is excited on the top gold square
- An image dipole is excited on the gold ground plane
- Resonance absorption can be explained by simple LCR circuit model
- LCR resonance frequency: \( f = \frac{\sqrt{2}}{2\pi\sqrt{LC}} \)
- Capacitance and mutual inductance: \( C = \varepsilon_0\varepsilon_r\frac{L^2}{2t} \)
- \( L = \mu_0\mu_r\)

\[ \lambda = \pi l n(\lambda) \]

Resonance wavelength

Theoretical considerations

- Selective infrared absorber. (a) in mid-, far-IR region by periodic gold squares (b) broadband absorber in UV and NIR formed by gold nano-islands.

- DC sputtered optically thin gold films are annealed to form gold nano-islands

Accuracy

- Reflectivity of SiO₂ and gold nano-islands measured using Cary500i UV-Vis-NIR spectrometer.

Summary

- We have experimentally demonstrated strong design-tunable absorption up to 99% in the near-UV, near-, mid-, and far-IR wavelength regions for surface composed of gold squares or islands separated from a gold plane by a SiO₂ dielectric layer. The positions of the resonances are predicted with reasonable accuracy using a simple analytic model.

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