Tamm plasmon resonance for sensing applications

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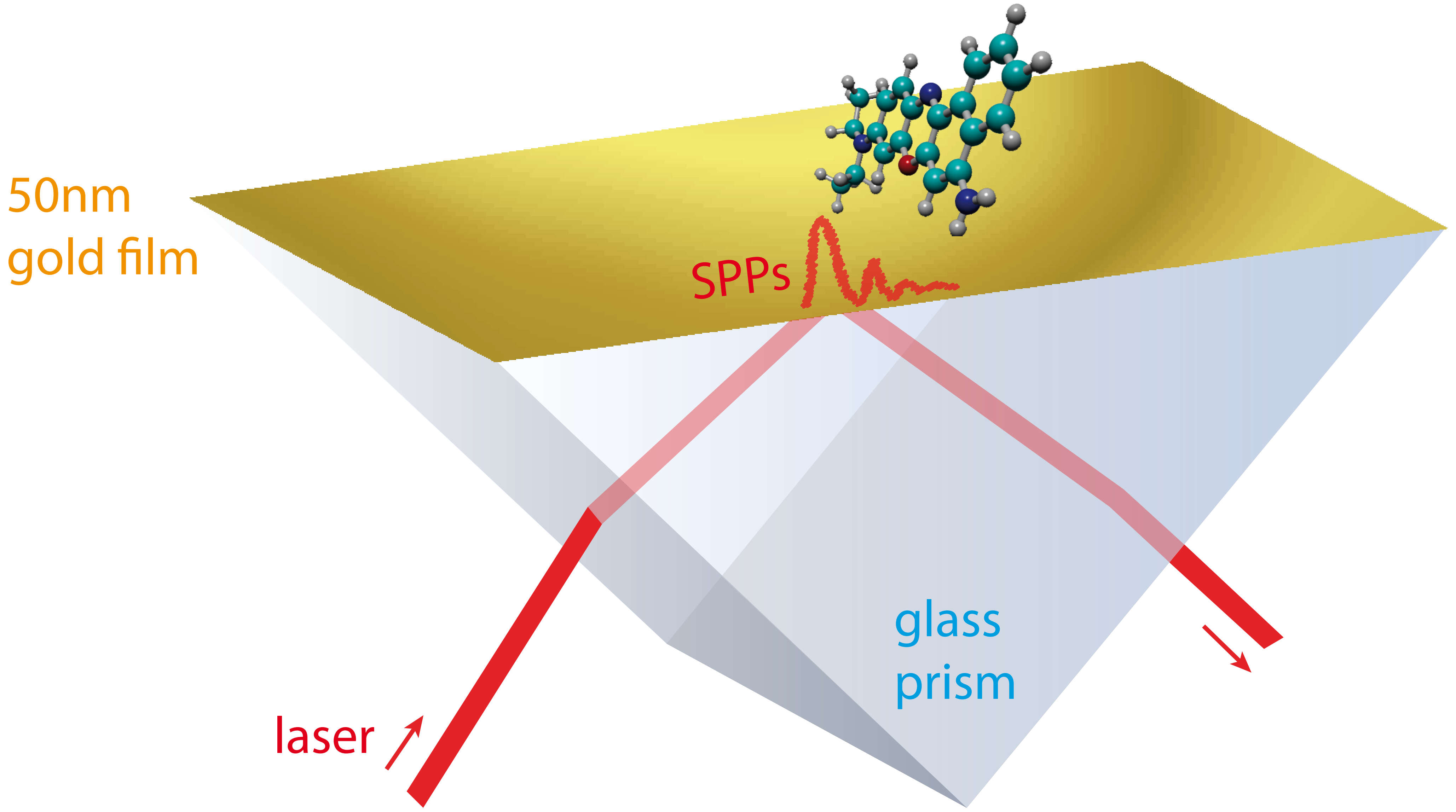
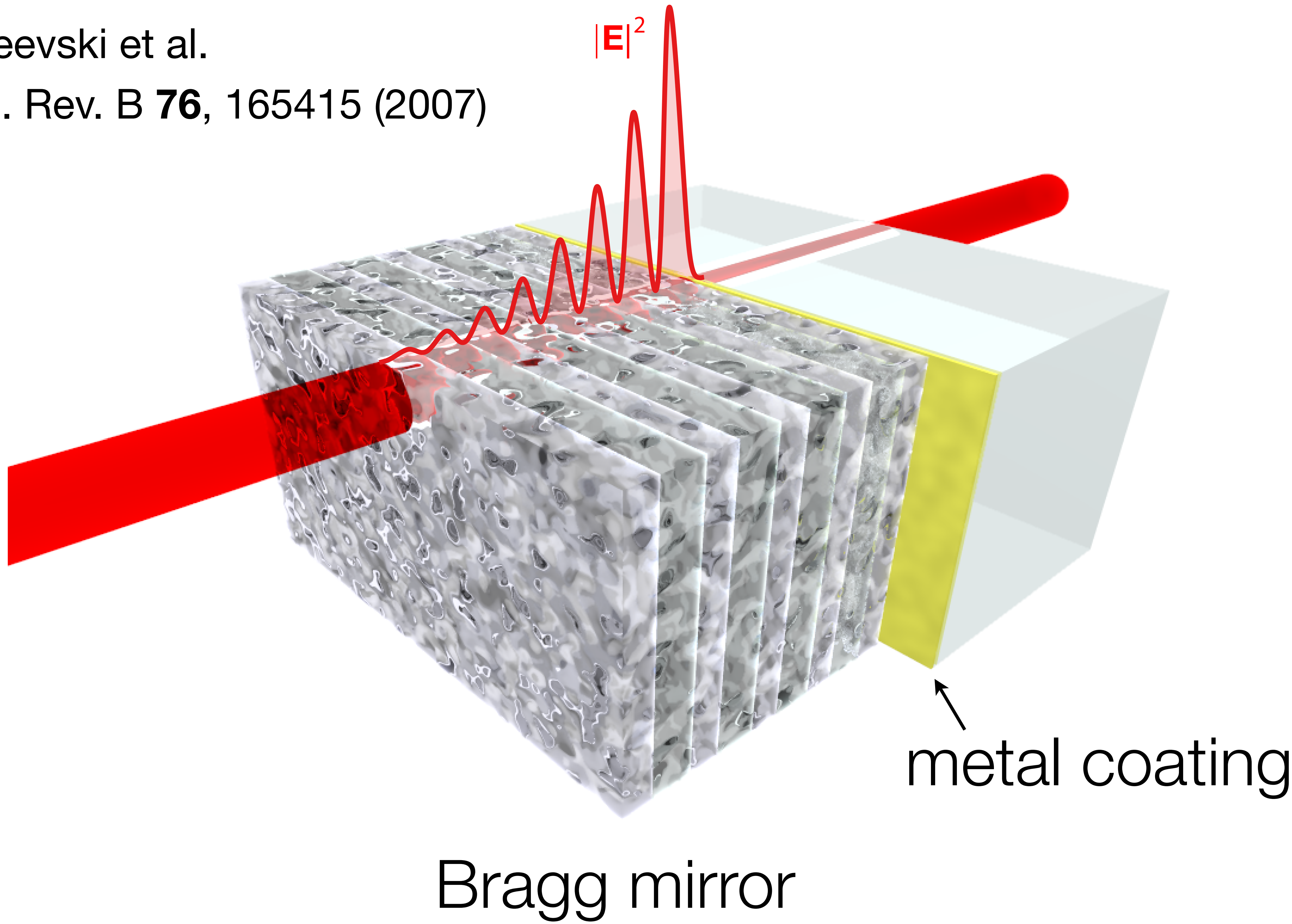
Surface plasmon resonance sensing



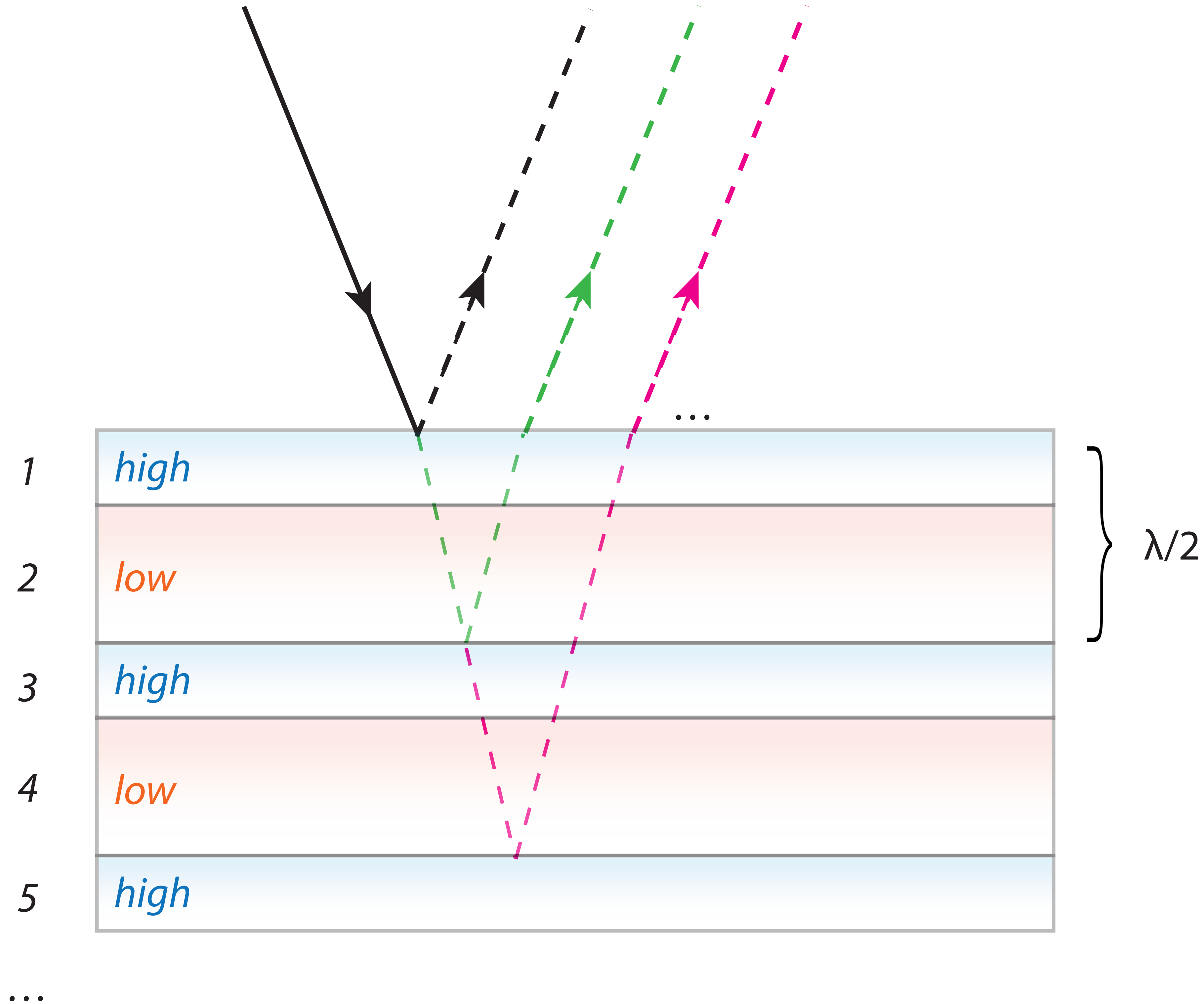
What are **Tamm plasmons** *??*

Kaliteevski et al.

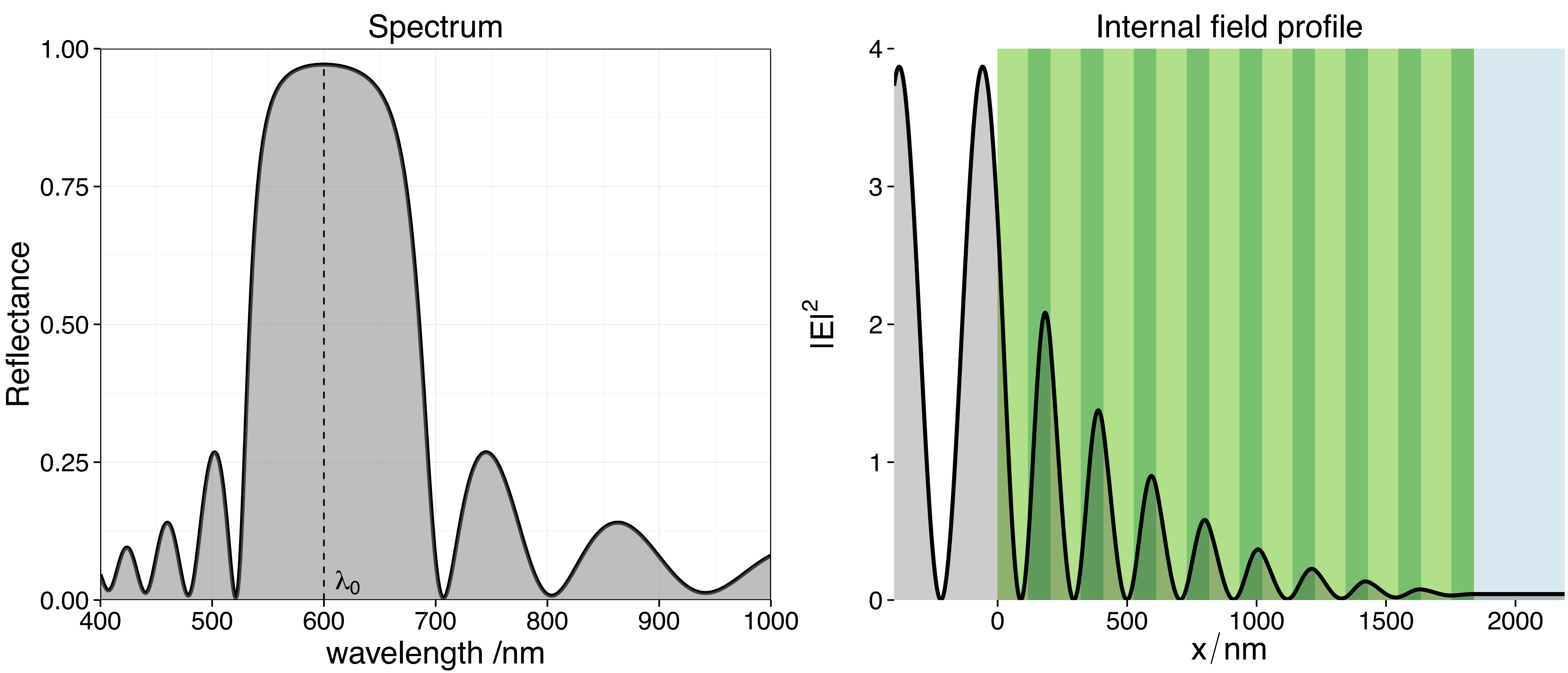
Phys. Rev. B **76**, 165415 (2007)



Distributed Bragg Reflector

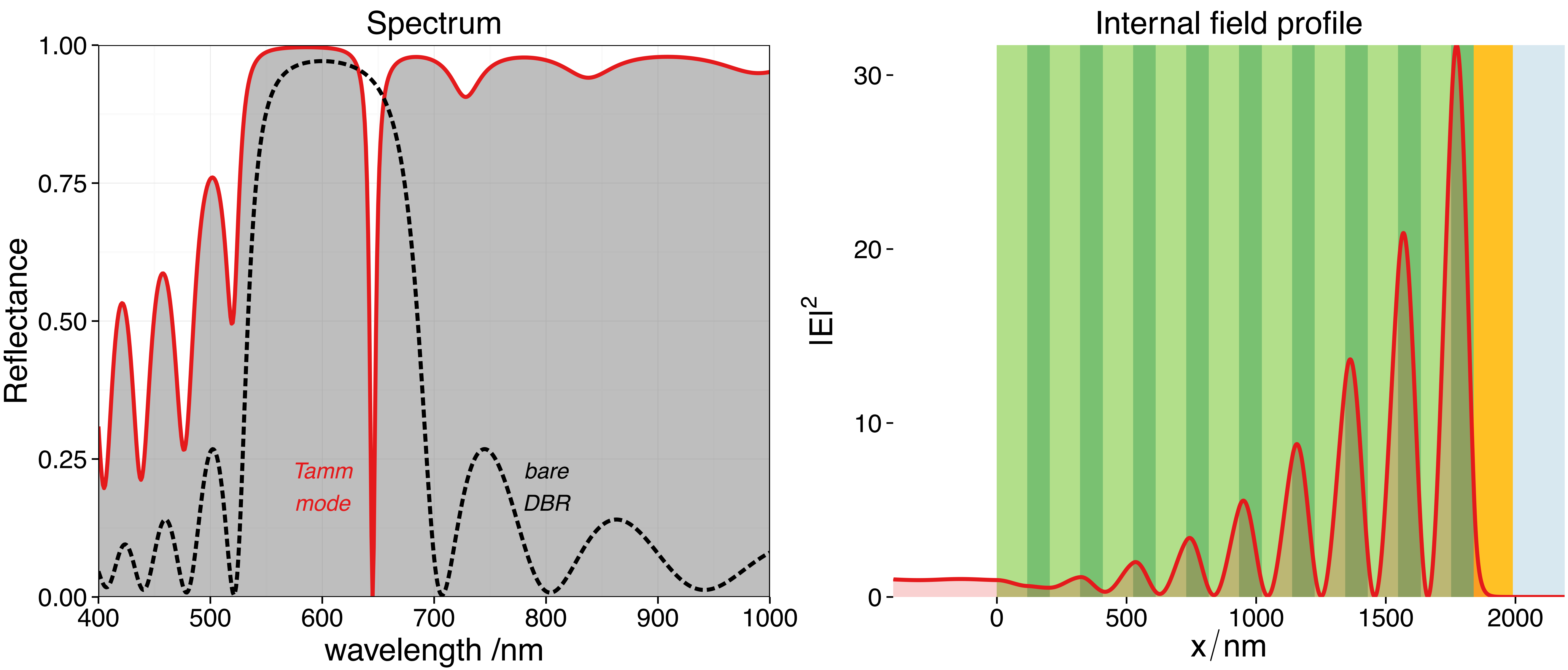


Distributed Bragg Reflector: optical response



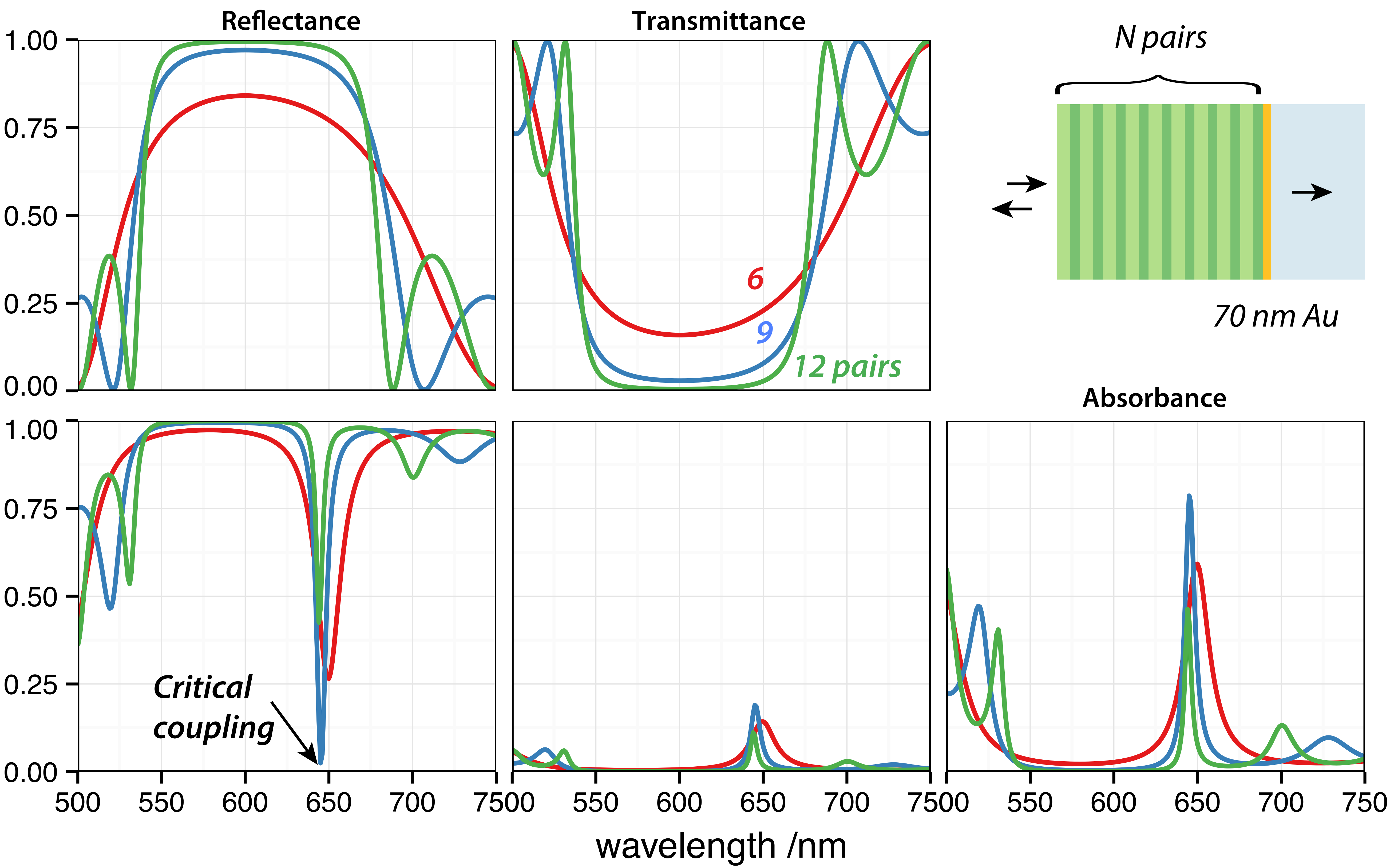
λ_0 =600nm, 9 pairs $\lambda_0/4$, n_1 =1.28, n_2=1.72

Tamm mode

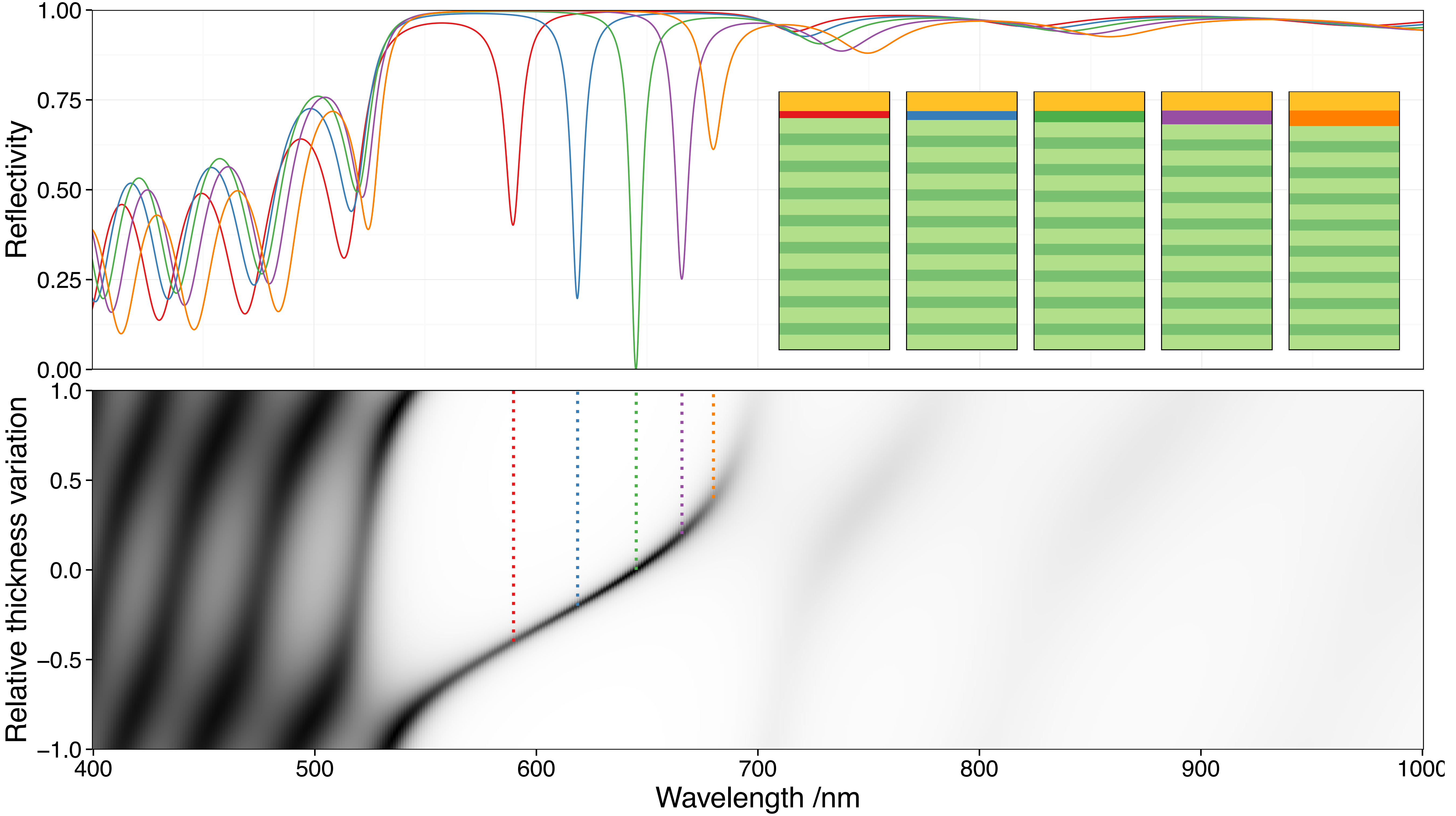


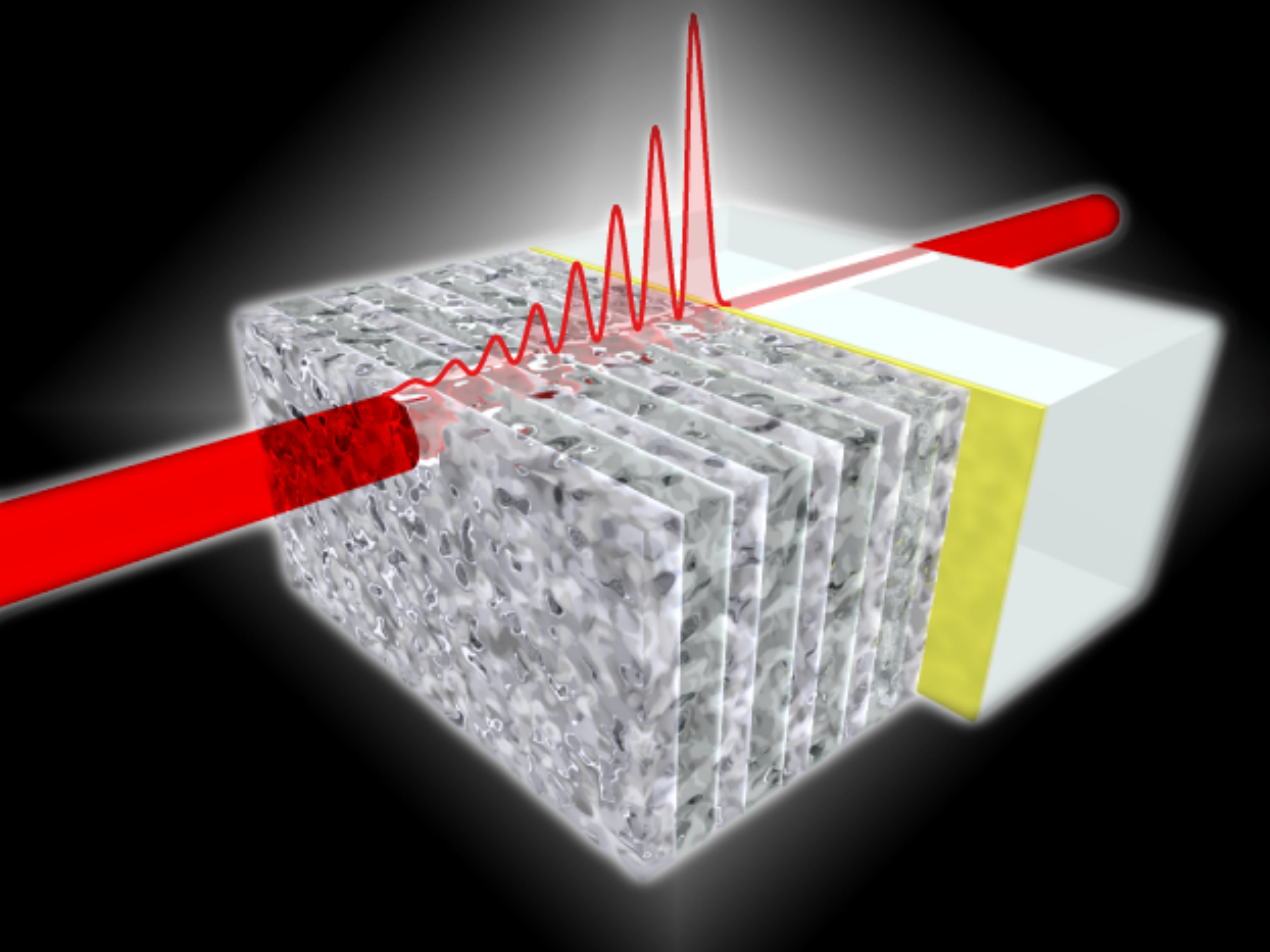
$\lambda_0 = 600\text{nm}$, 9 pairs $\lambda_0/4$, $n_1 = 1.28$, $n_2 = 1.72$, **150 nm Au**

- **Transmittance / Absorbance ratio** depends on DBR and metal thickness
- Large absorbance means **strong electric field** near the metal layer

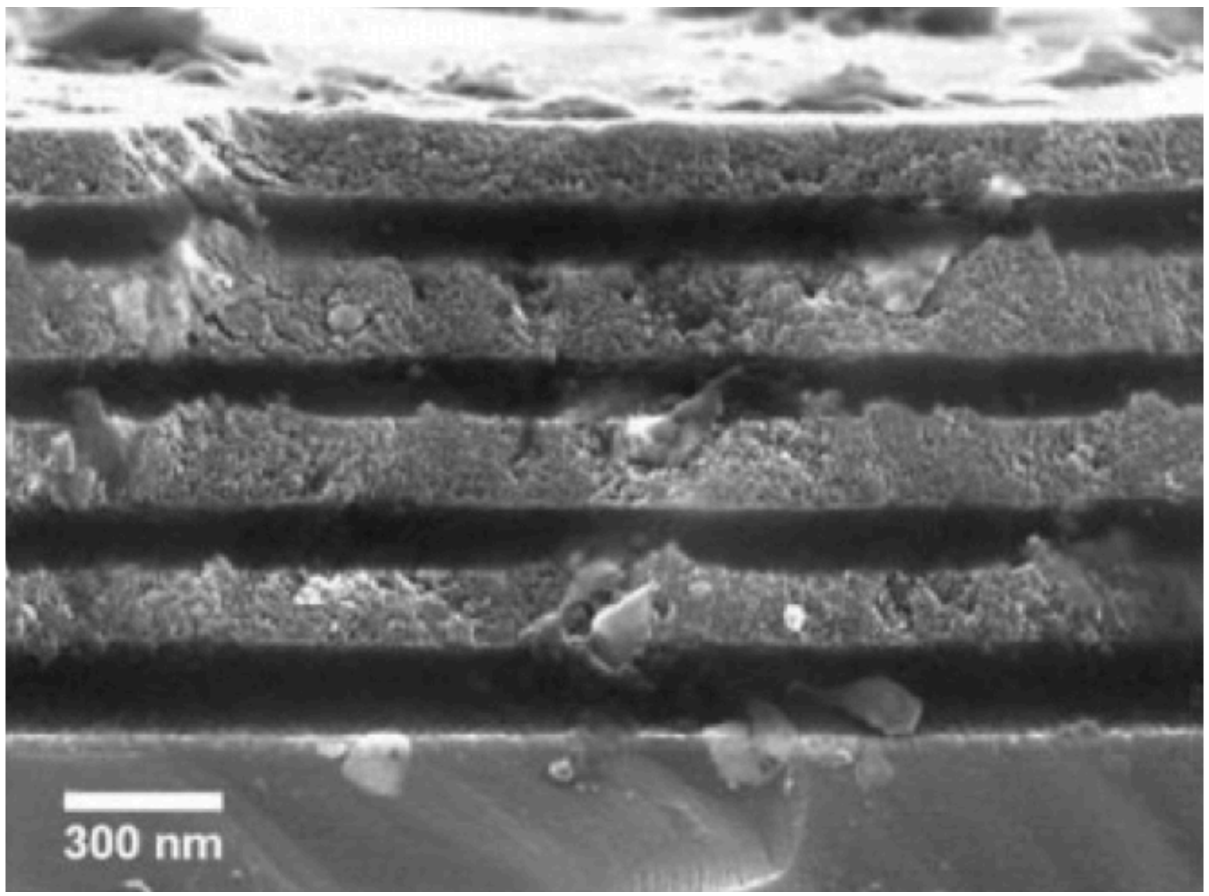


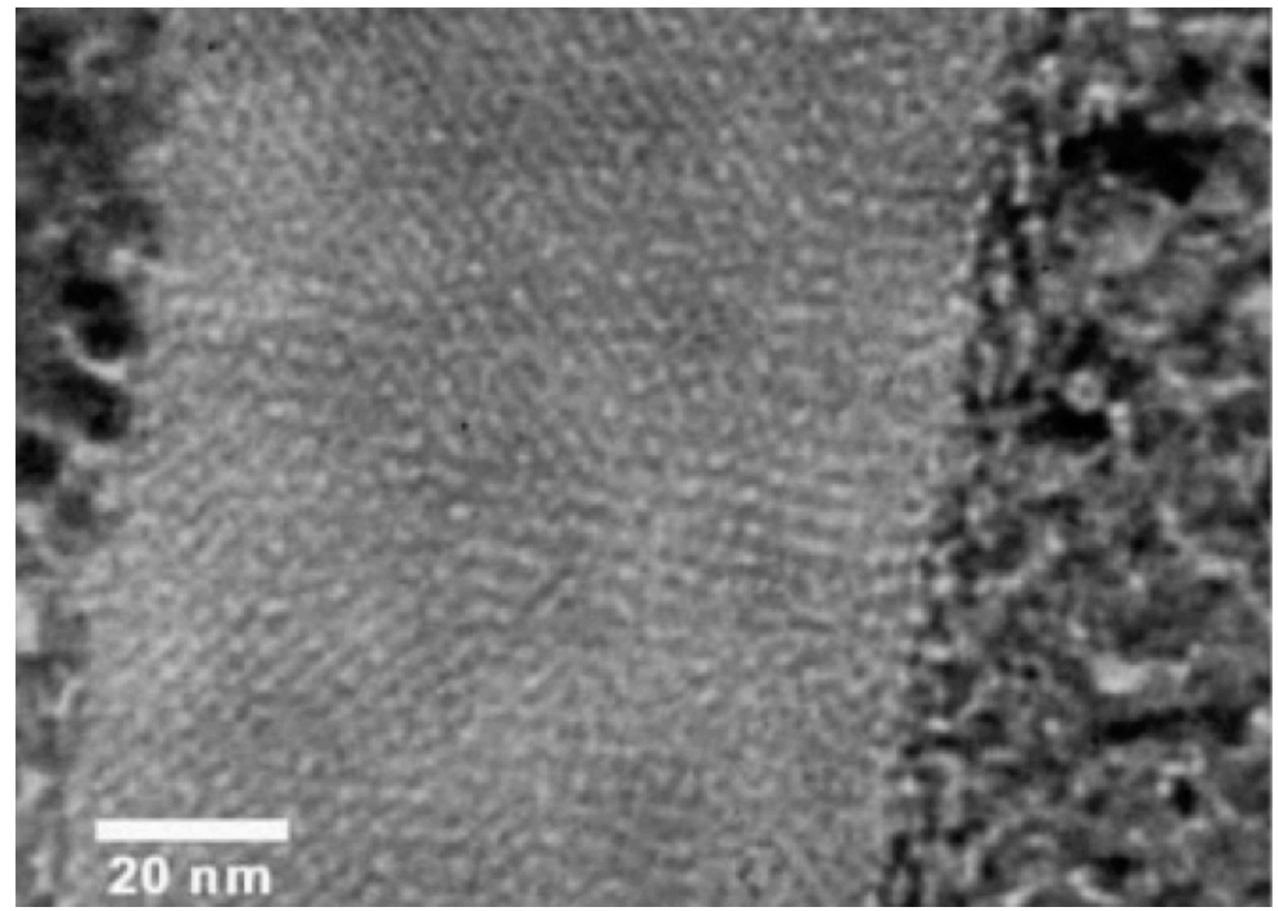
Tunability


1.00
0.75
0.50
0.25
0.00
Reflectivity
1.0
0.5
0.0
−0.5
−1.0
Relative thickness variation
400
500
600
700
800
900
1000
Wavelength /nm



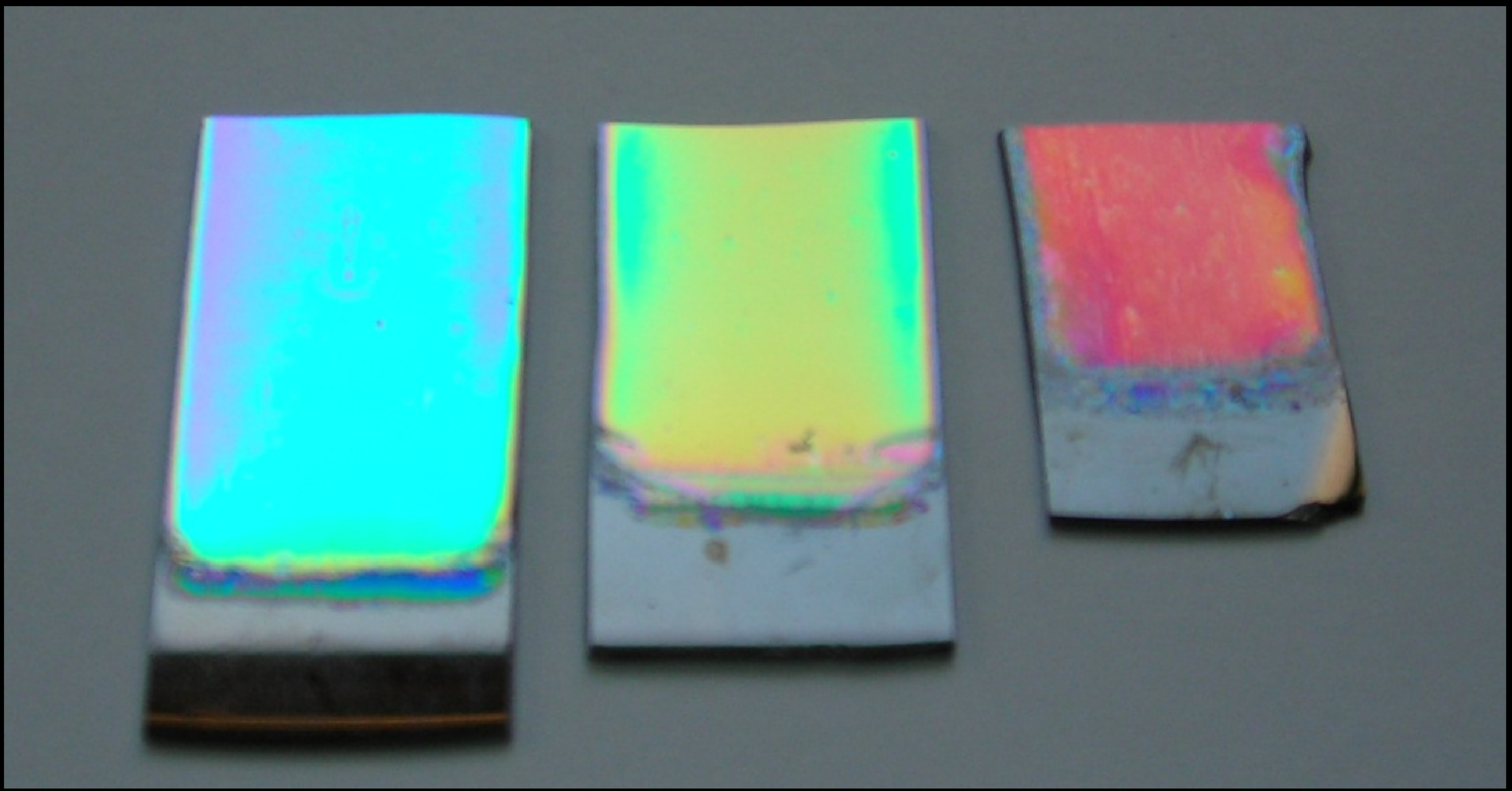
Porous Bragg mirrors

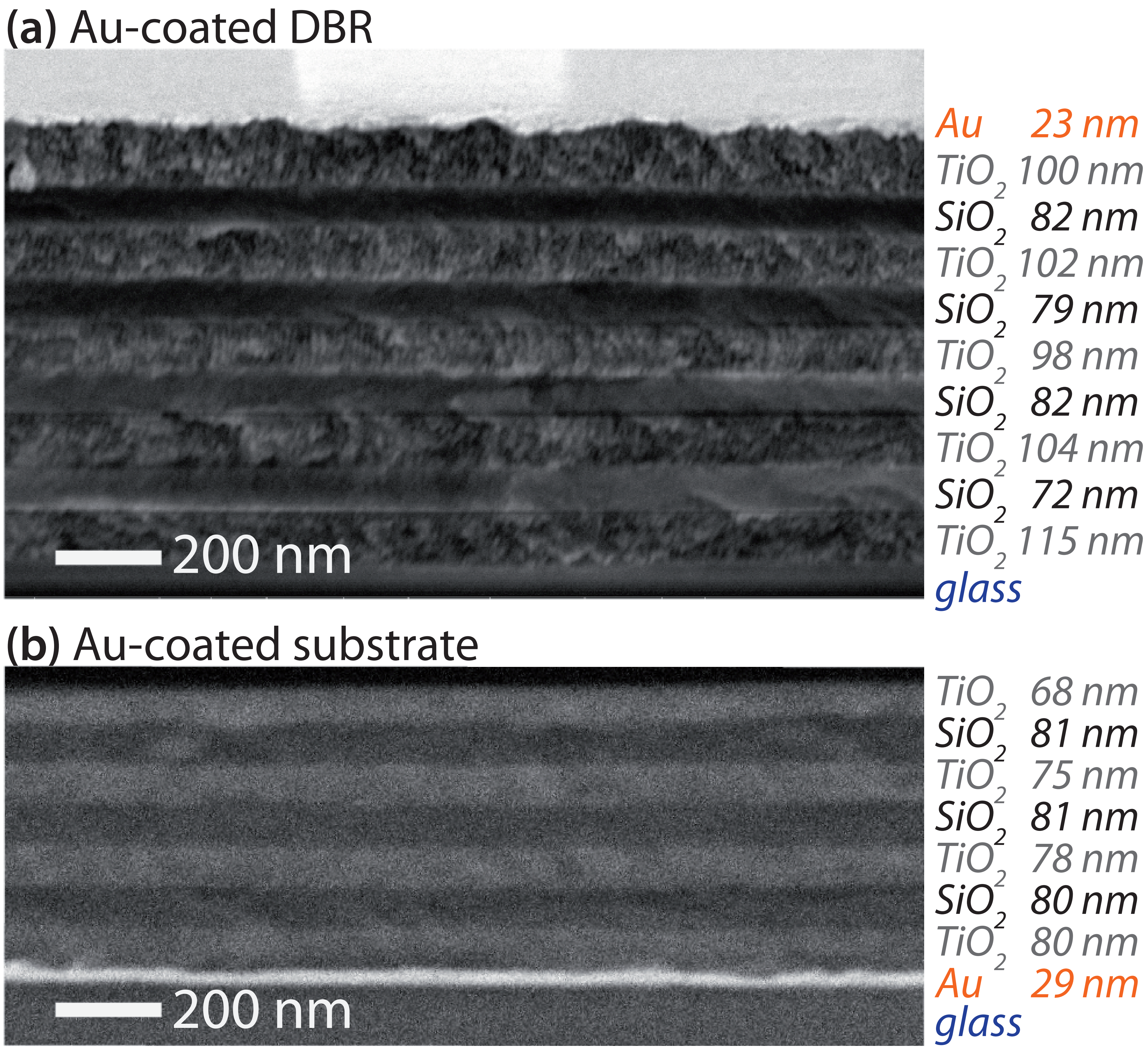


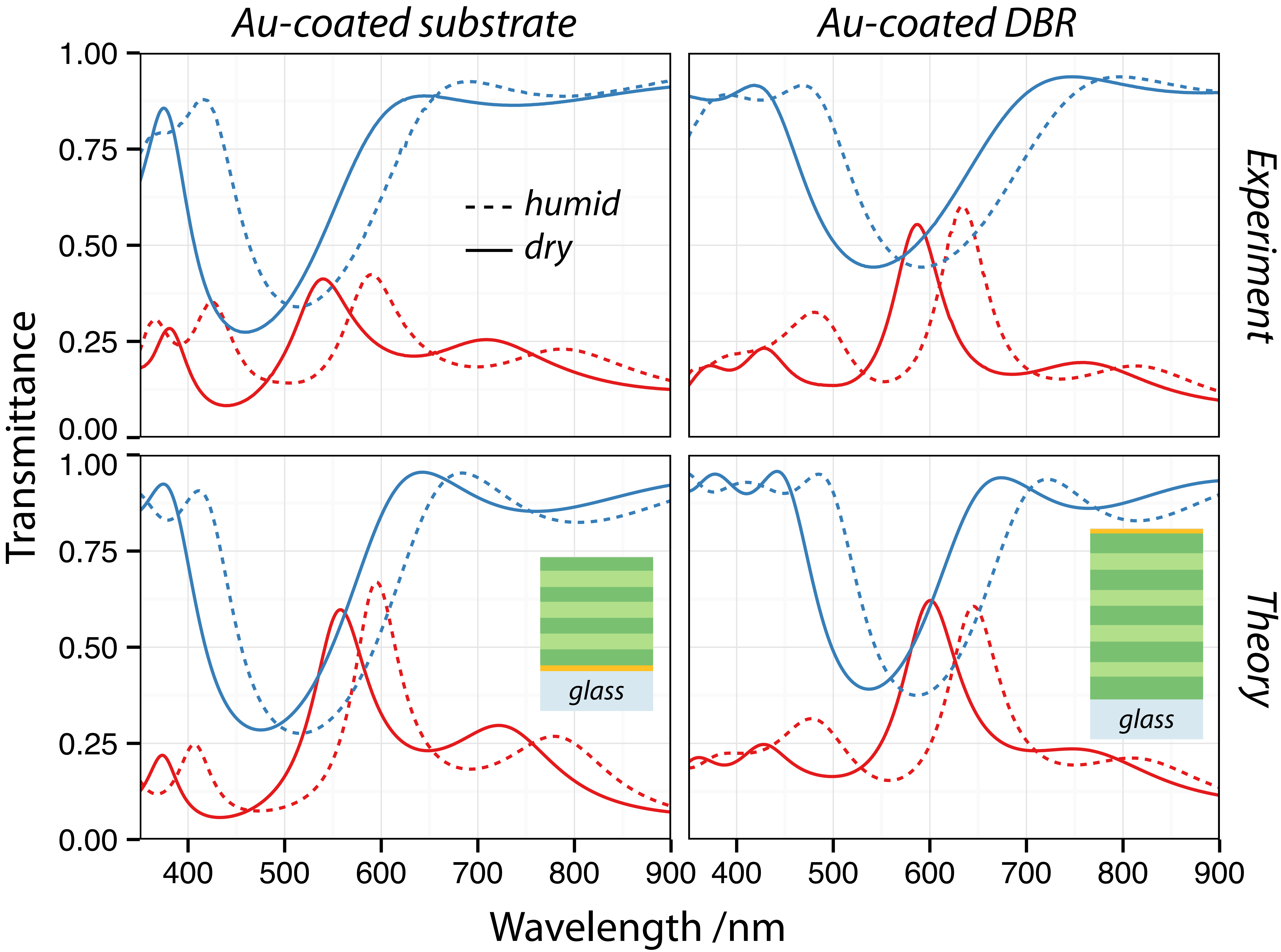


Adv. Mat. 18, 2397–2402 (2006)
Adv. Func. Mat. 17, 1247–1254 (2007)
J. Phys. Chem. C 112, 3157–3163 (2008)

Wavelength-selective mirrors

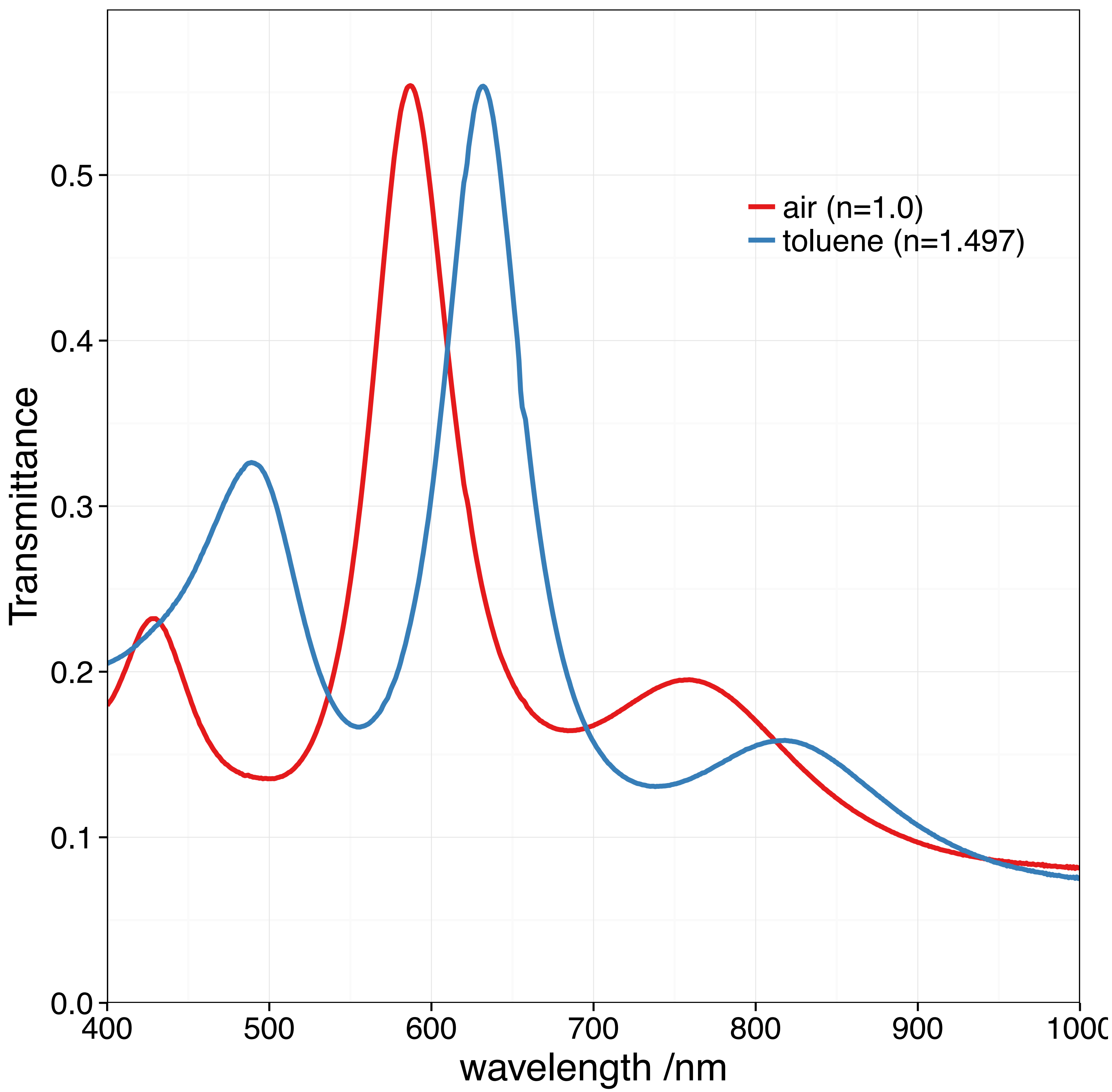



(a) Au-coated DBR
Au 23 nm
TiO2 100 nm
SiO2 82 nm
TiO2 102 nm
SiO2 79 nm
TiO2 98 nm
SiO2 82 nm
TiO2 104 nm
SiO2 72 nm
TiO2 115 nm
glass
200 nm
(b) Au-coated substrate
TiO2 68 nm
SiO2 81 nm
TiO2 75 nm
SiO2 81 nm
TiO2 78 nm
SiO2 80 nm
TiO2 80 nm
Au 29 nm
glass
200 nm



Au-coated substrate
Au-coated DBR
Experiment
Theory
humid
dry
glass
glass
Transmittance
1.00
0.75
0.50
0.25
0.00
400
500
600
700
800
900
Wavelength /nm

Sensing (proof-of-principle)



45 nm shift

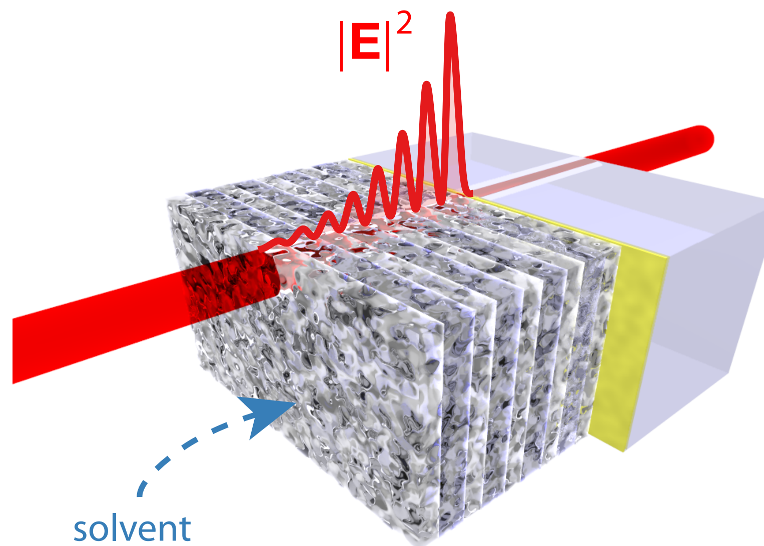
40% porosity

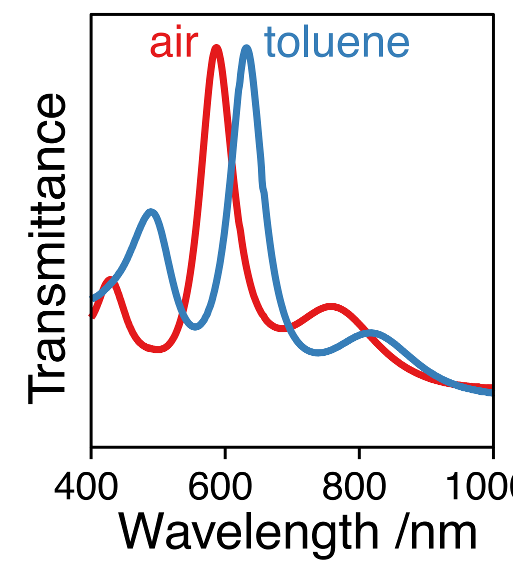
↓

200 nm RIU^{-1}

Perspectives

- gas sensing
- Raman and fluorescence
- hybrid cavity-Tamm plasmon
- inclusion of metal nanoparticles





References

[*Tamm sensor*] ACS Photonics, (2014) 1(9):775–780

[*Critical coupling*] Journal of Optics, (just accepted, 2014) arXiv:1411.0608

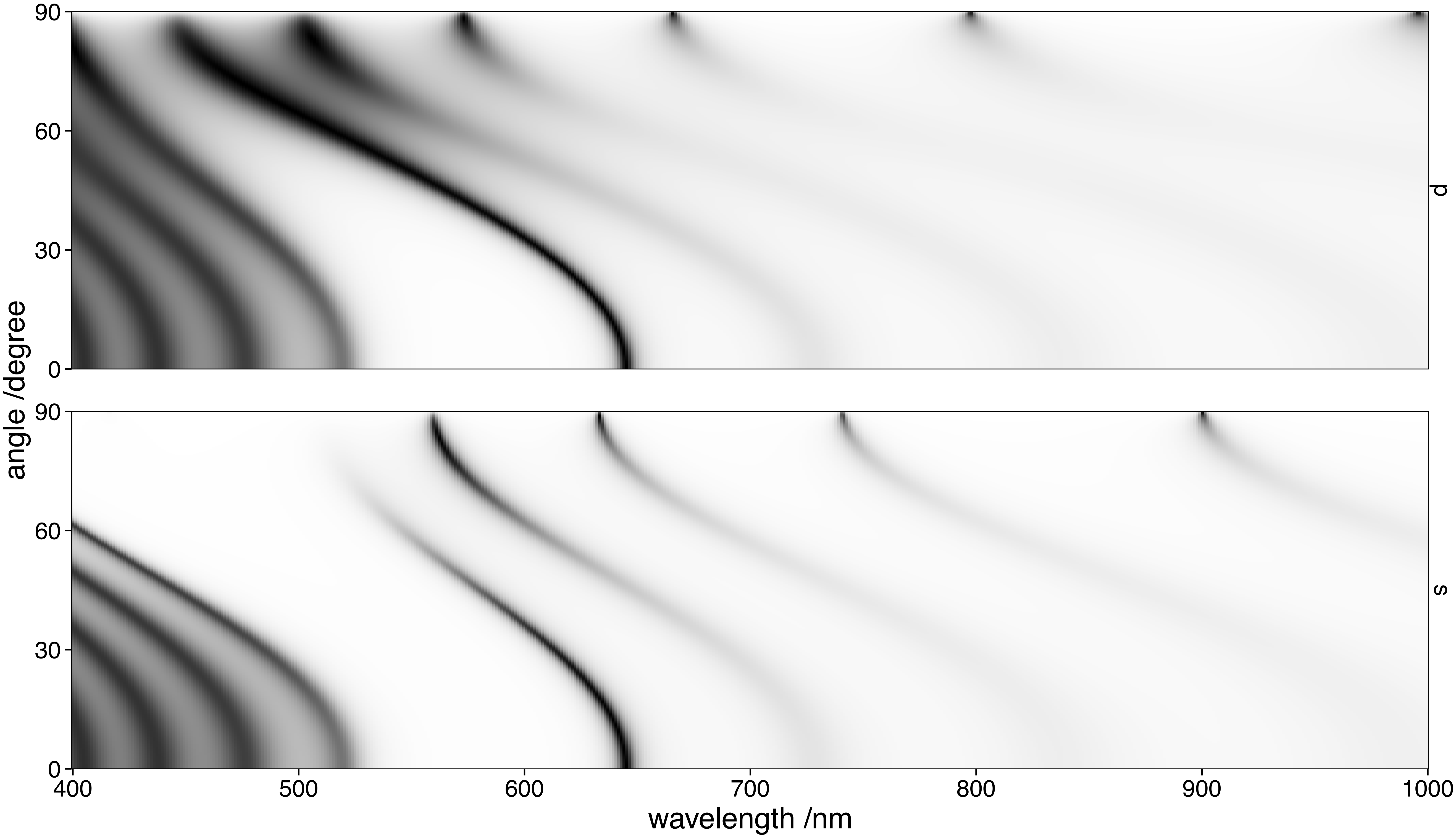
¡Thank you for your attention!

contact: `baptiste.auguie@vuw.ac.nz`

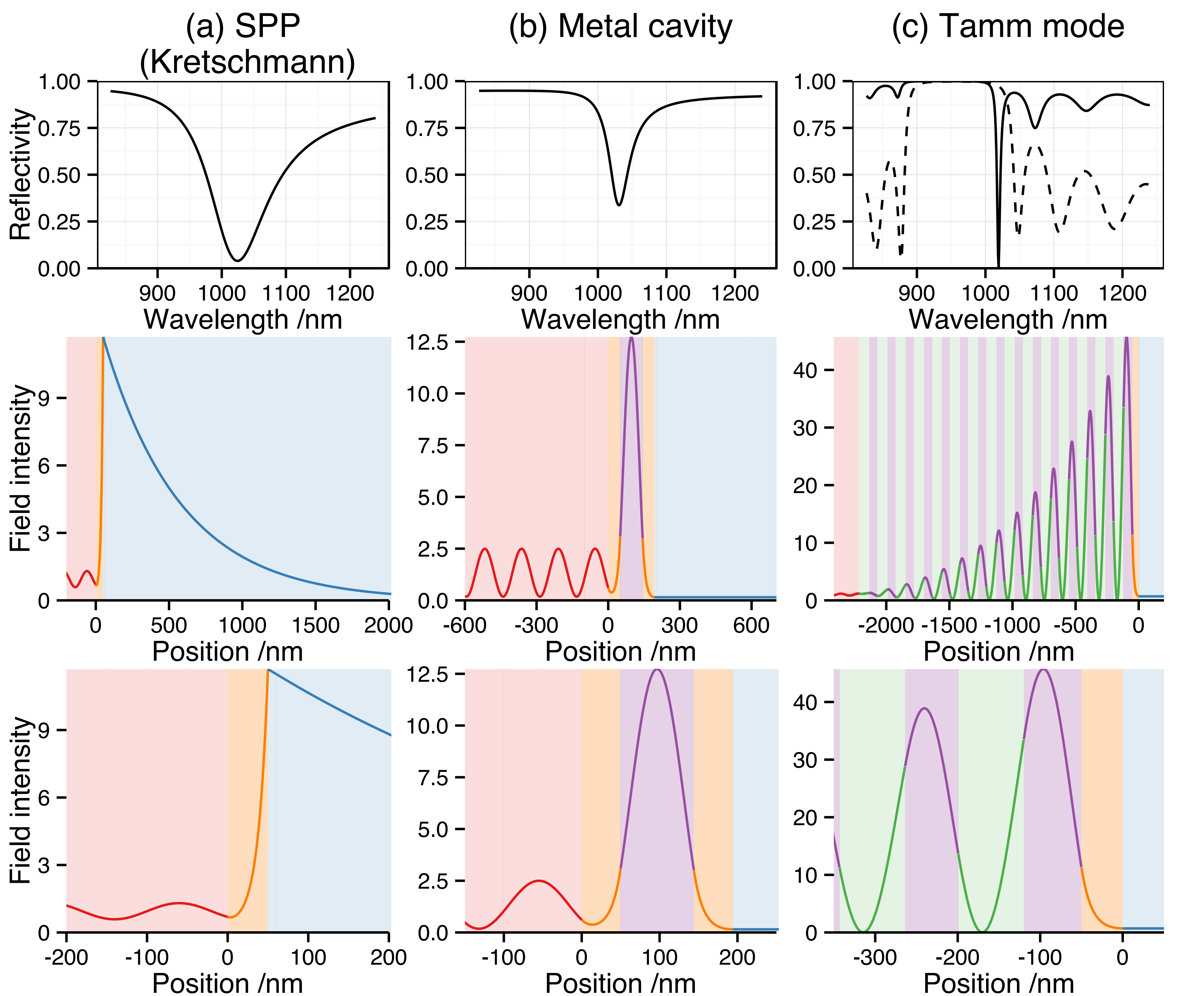
Icing on the cake

supporting information

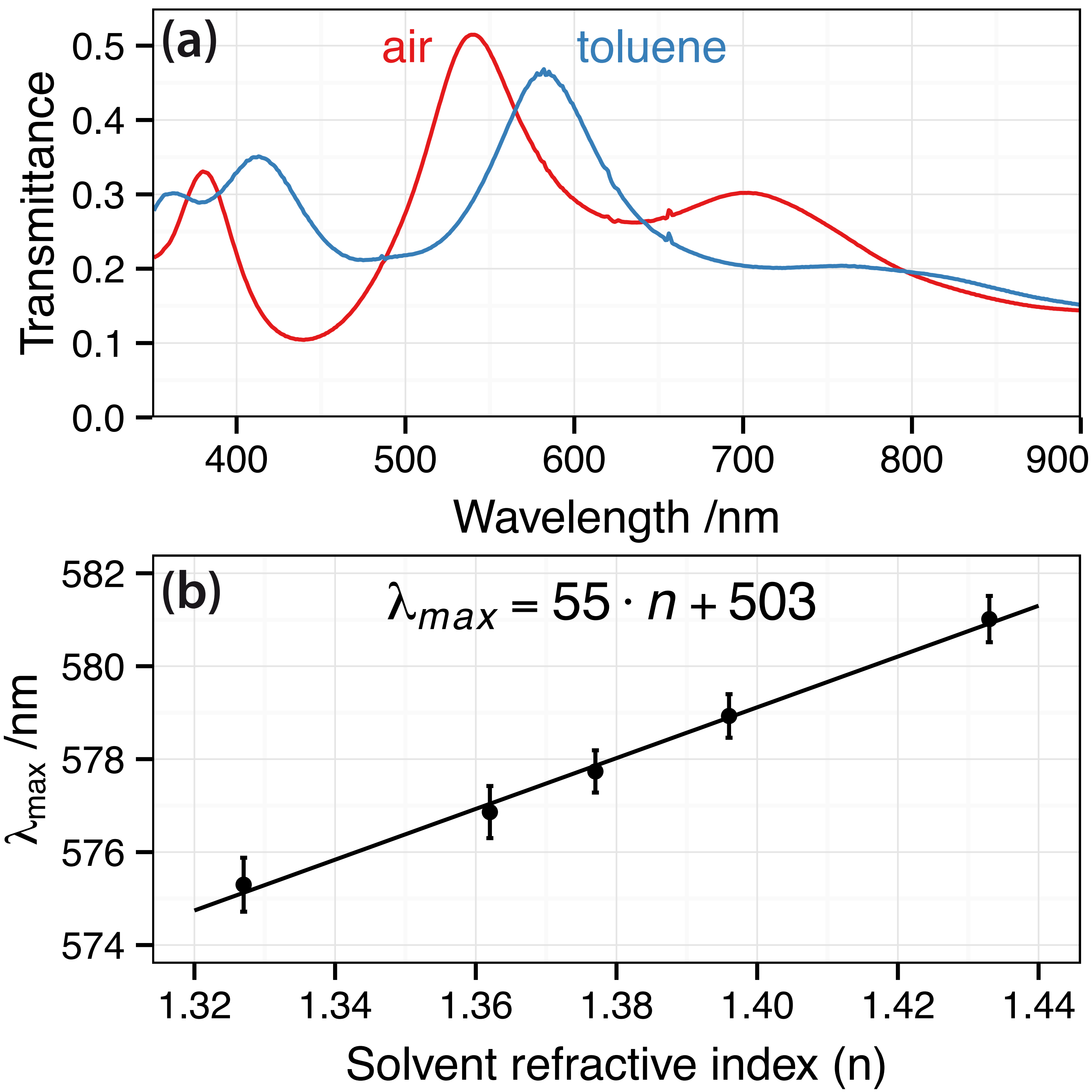
Dispersion of the mode (TE and TM)



Comparisons

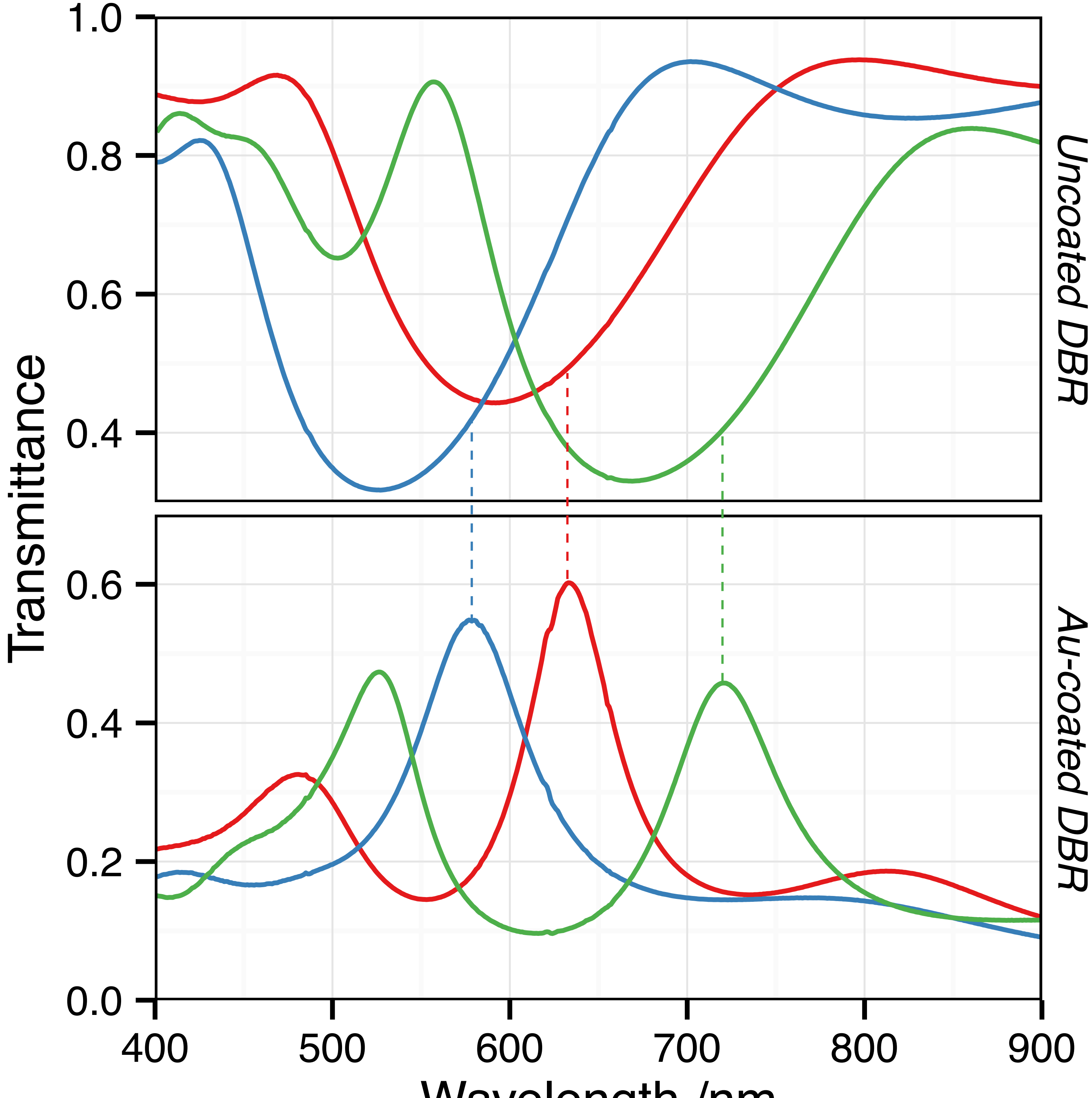


Sensing



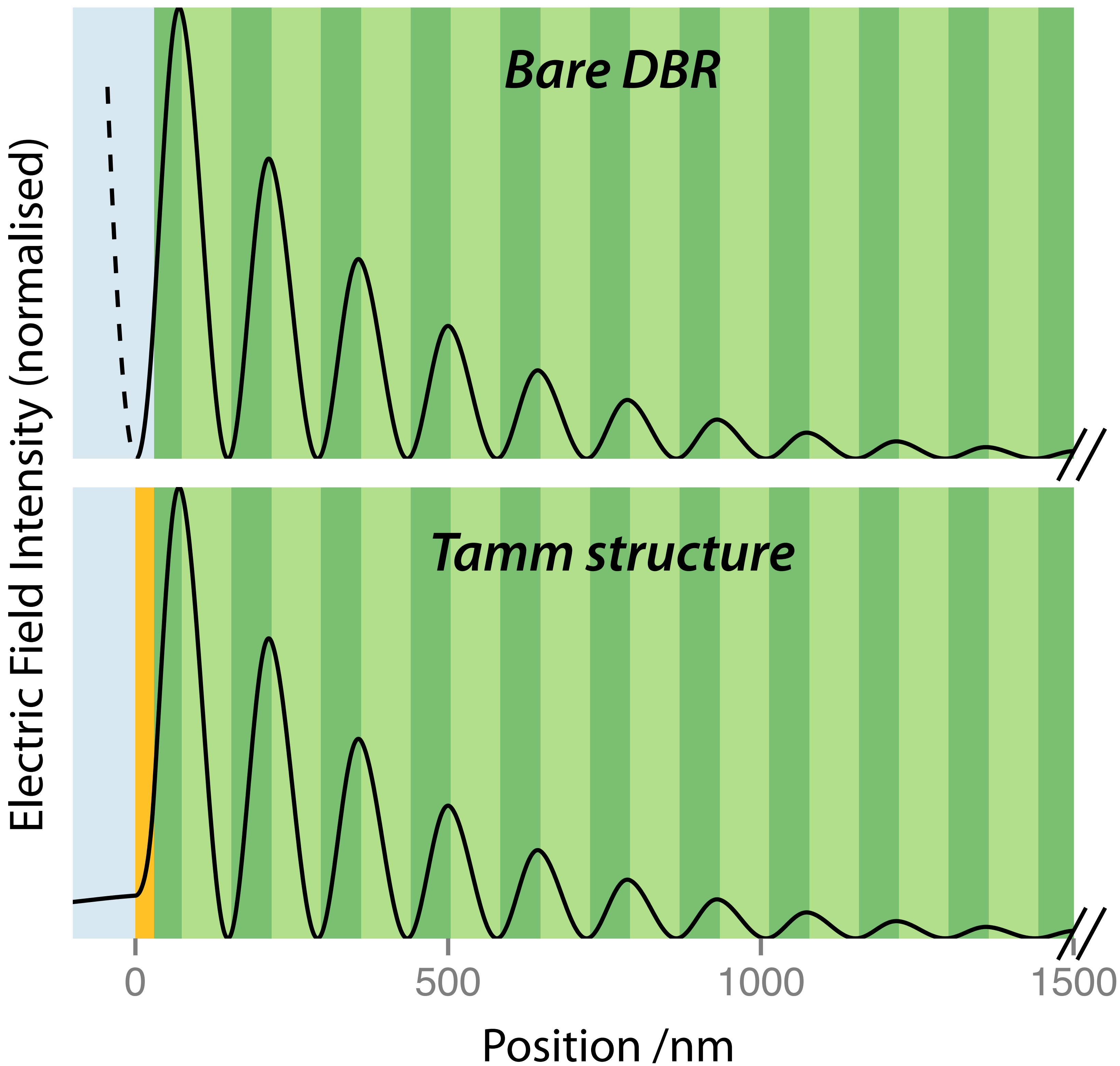
(a)
air
toluene
Transmittance
0.0
0.1
0.2
0.3
0.4
0.5
400
500
600
700
800
900
Wavelength /nm
(b)
$\lambda_{max} = 55 \cdot n + 503$
λ_{max} /nm
574
576
578
580
582
1.32
1.34
1.36
1.38
1.40
1.42
1.44
Solvent refractive index (n)

Tunability

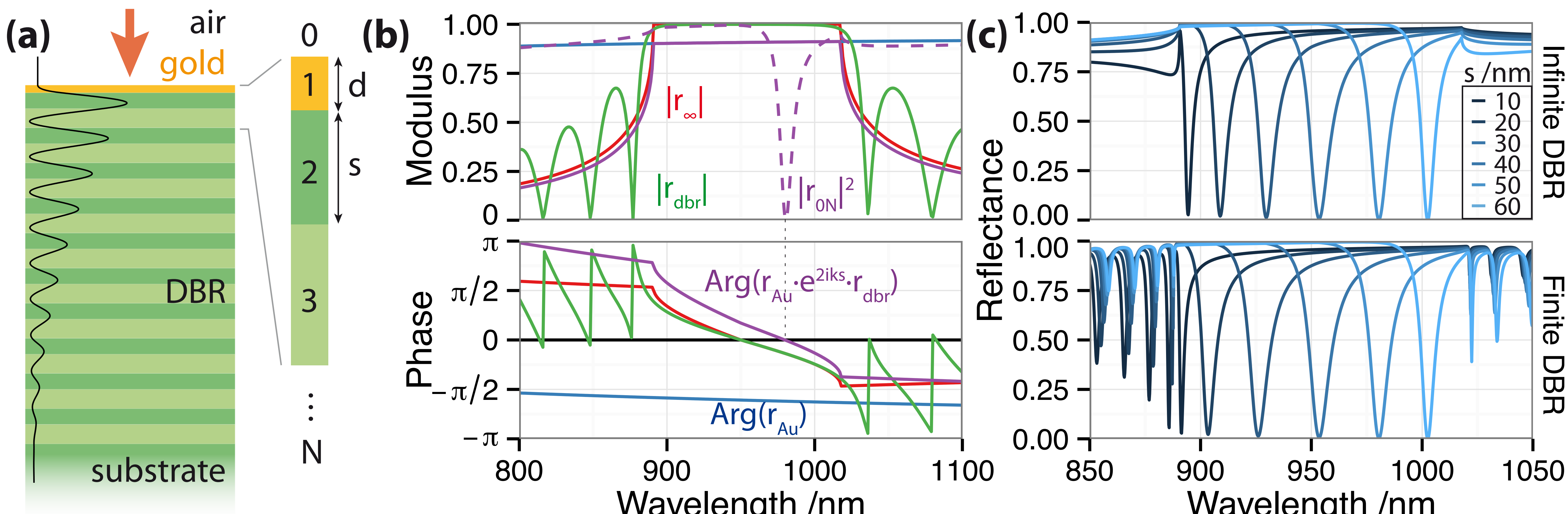


1.0
0.8
0.6
0.4
0.6
0.4
0.2
0.0
400
500
600
700
800
900
Wavelength /nm
Transmittance
Uncoated DBR
Au-coated DBR

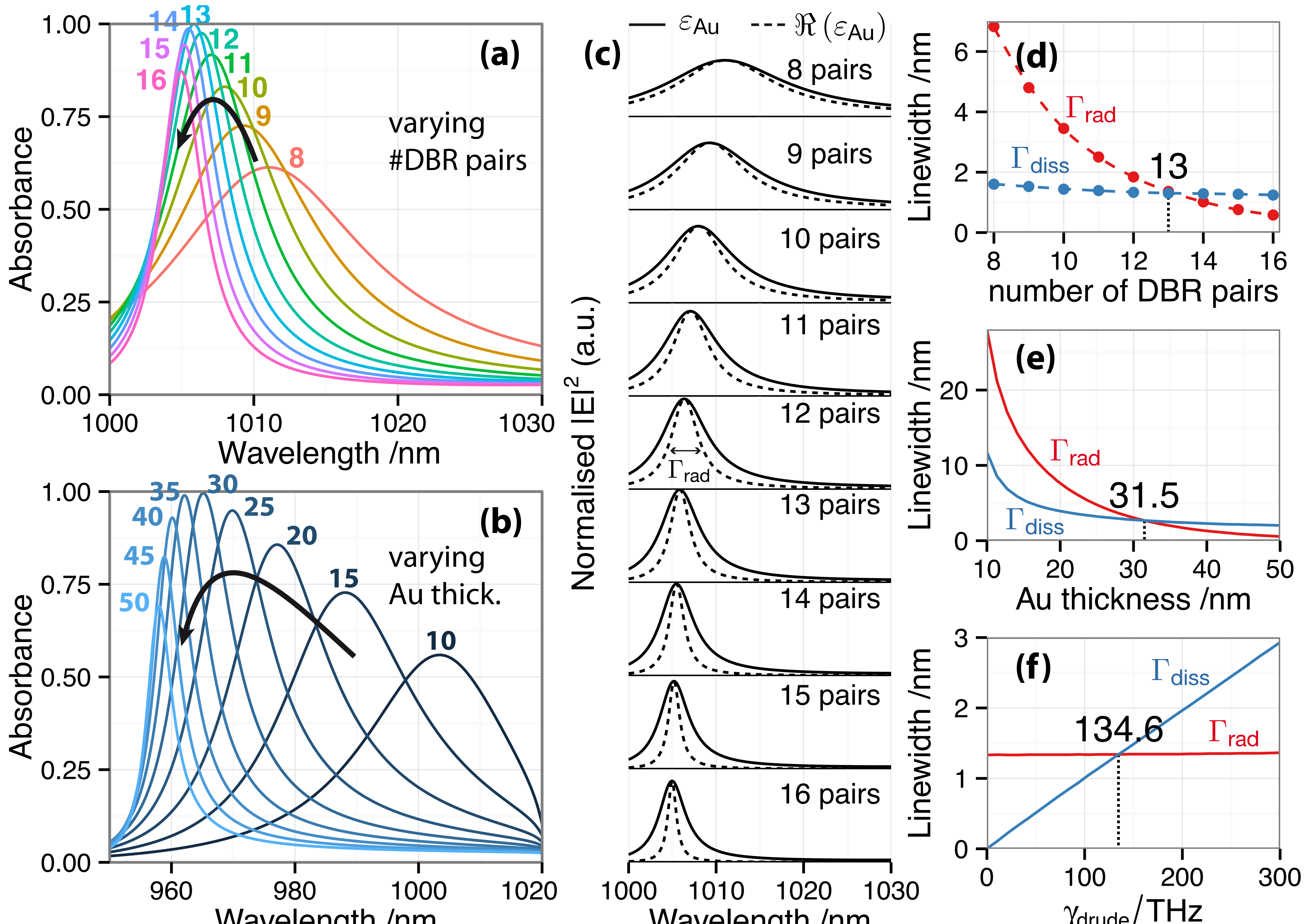
Field profile



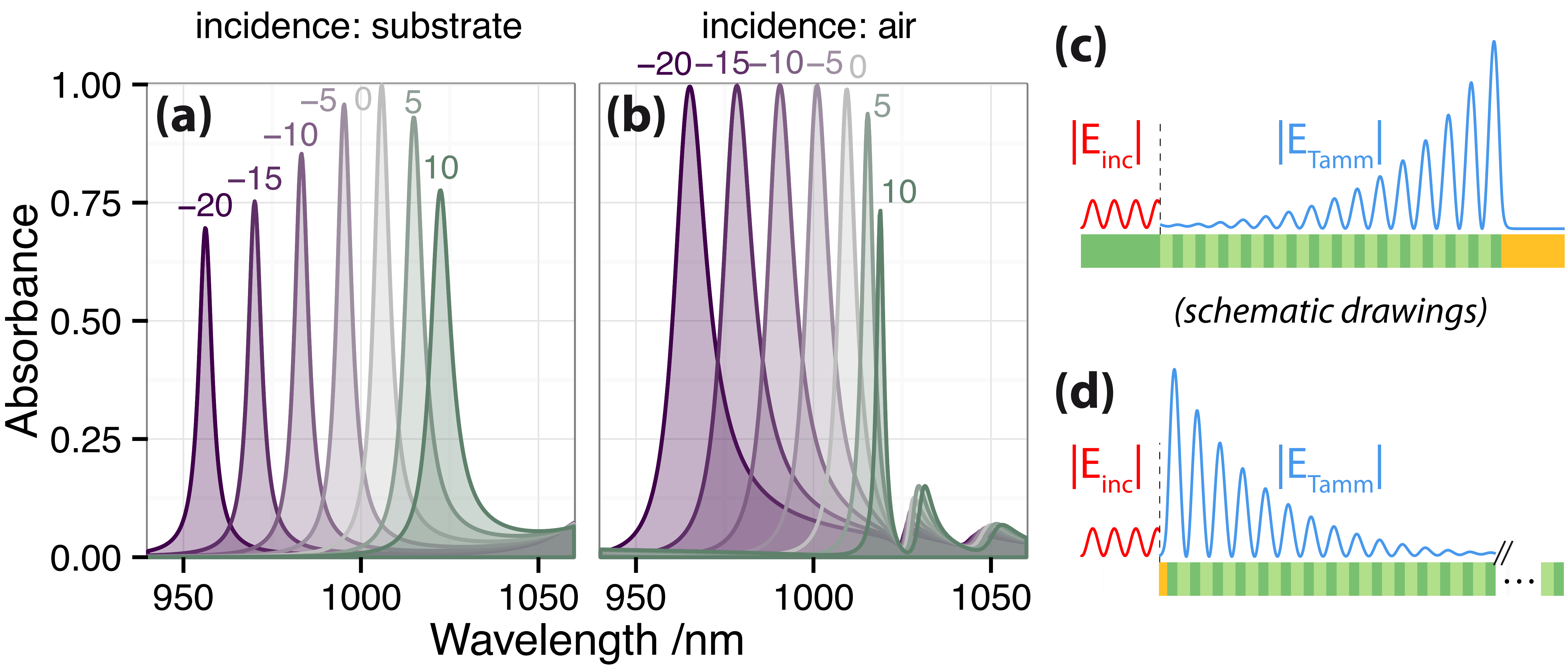
Resonance condition



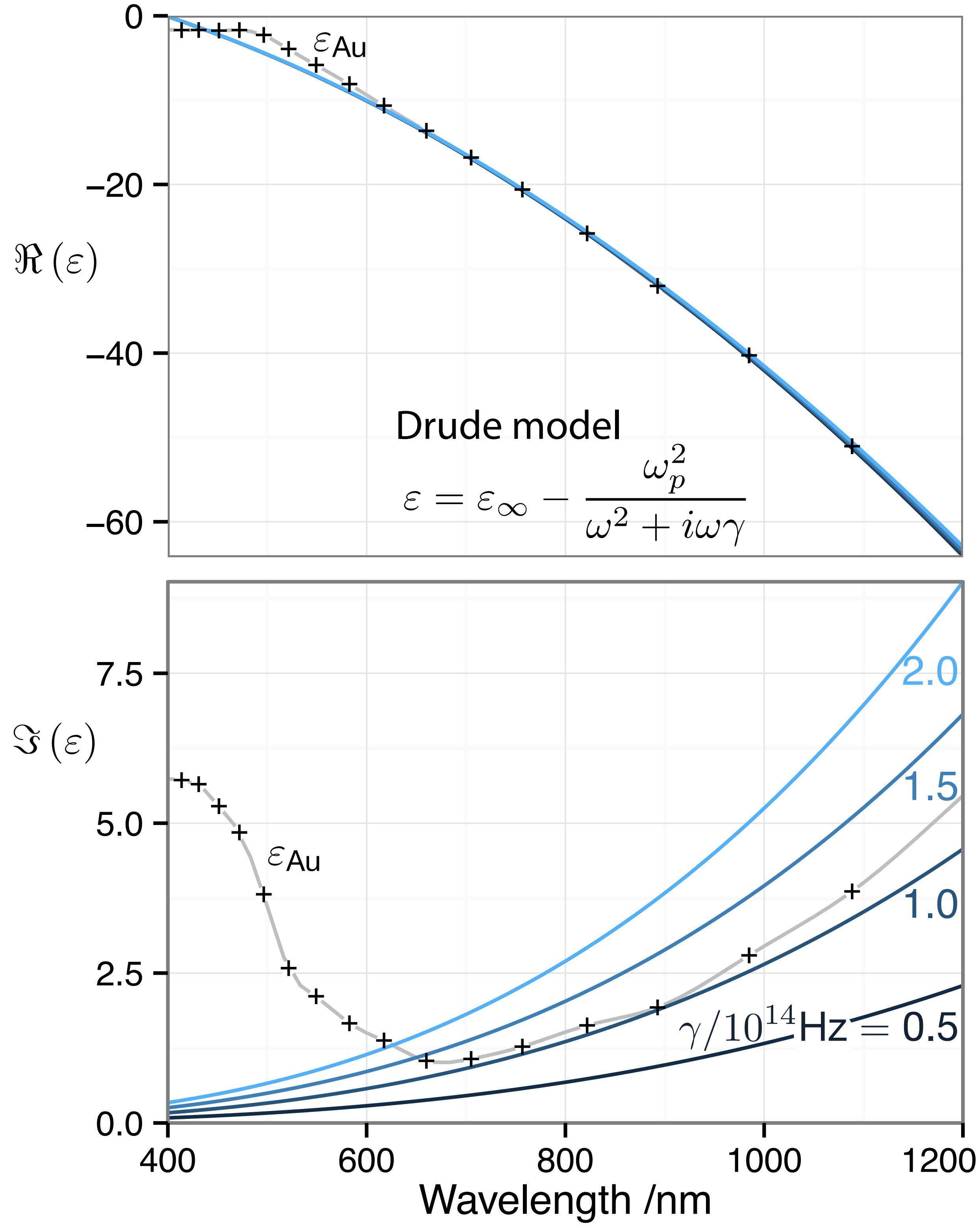
Critical coupling



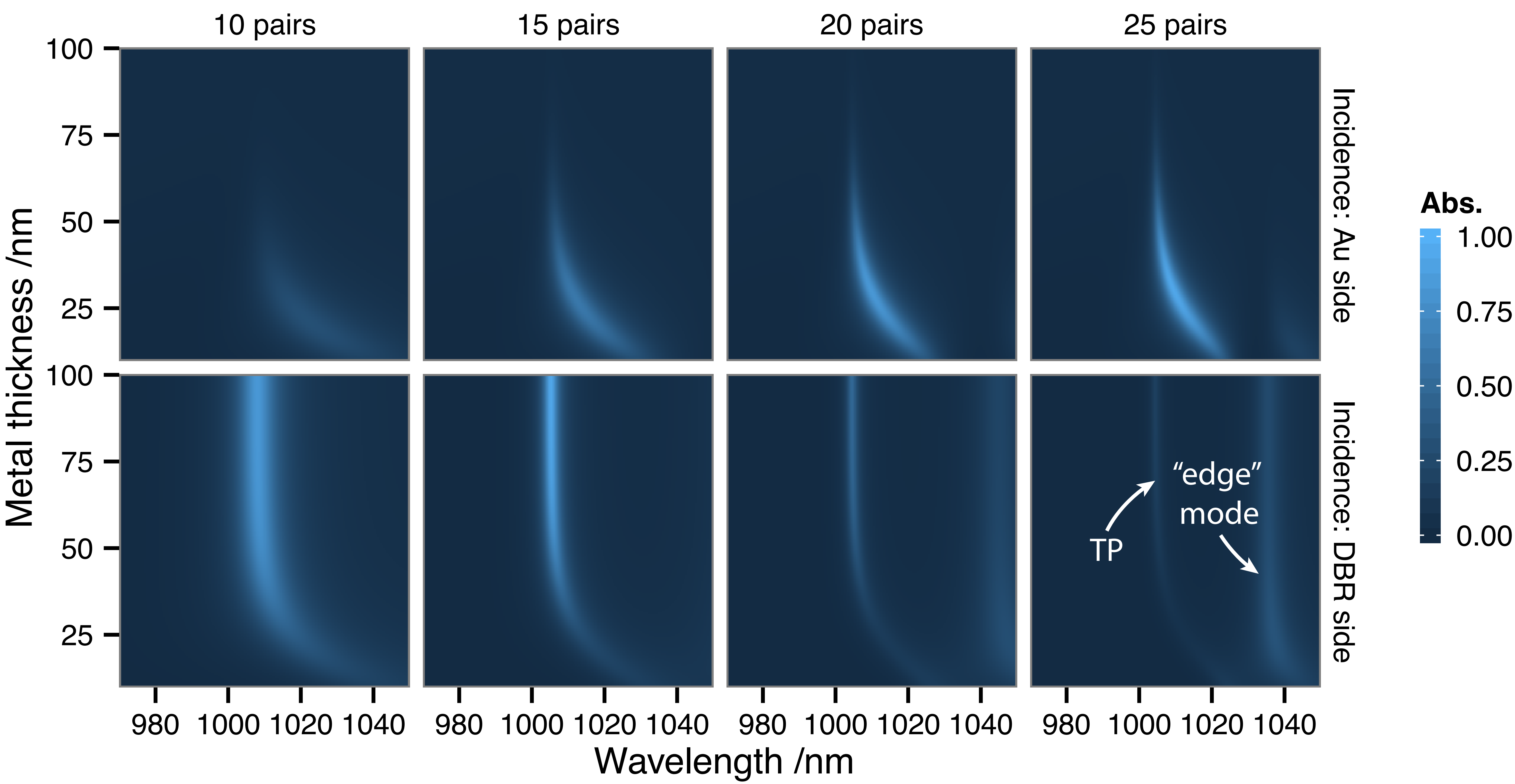
Tunability of critical coupling



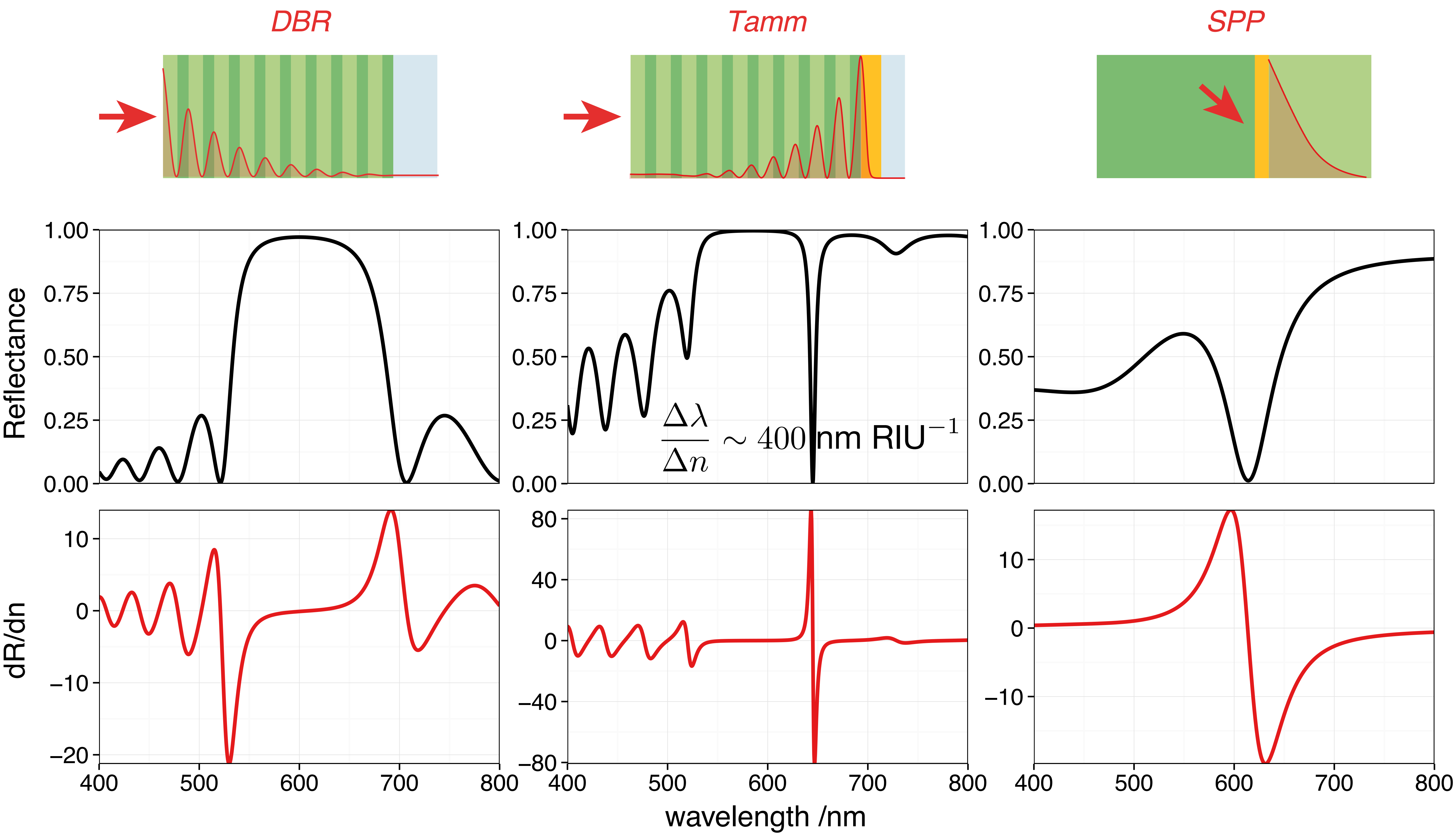
Dielectric function



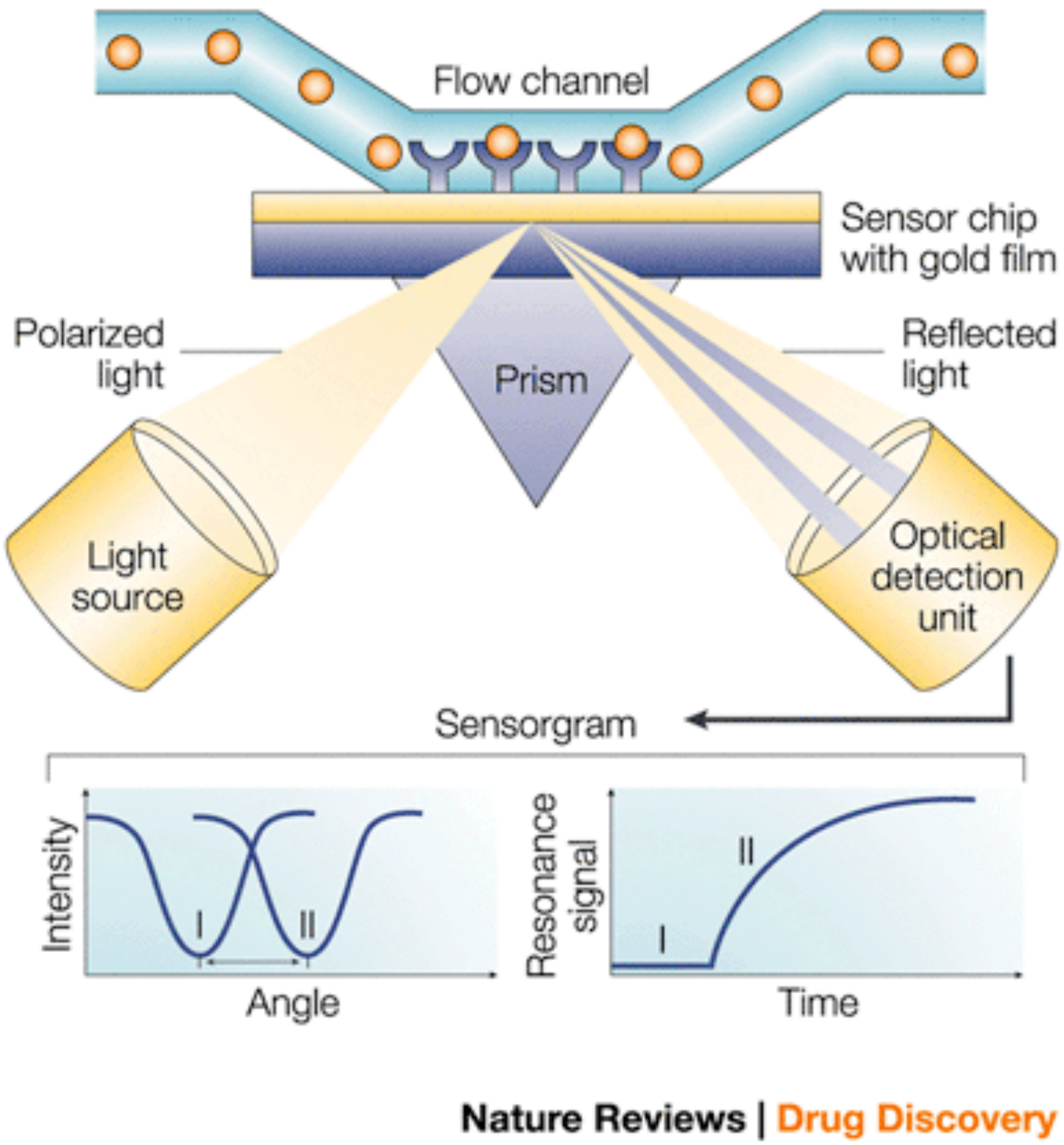
Critical coupling & perfect absorption

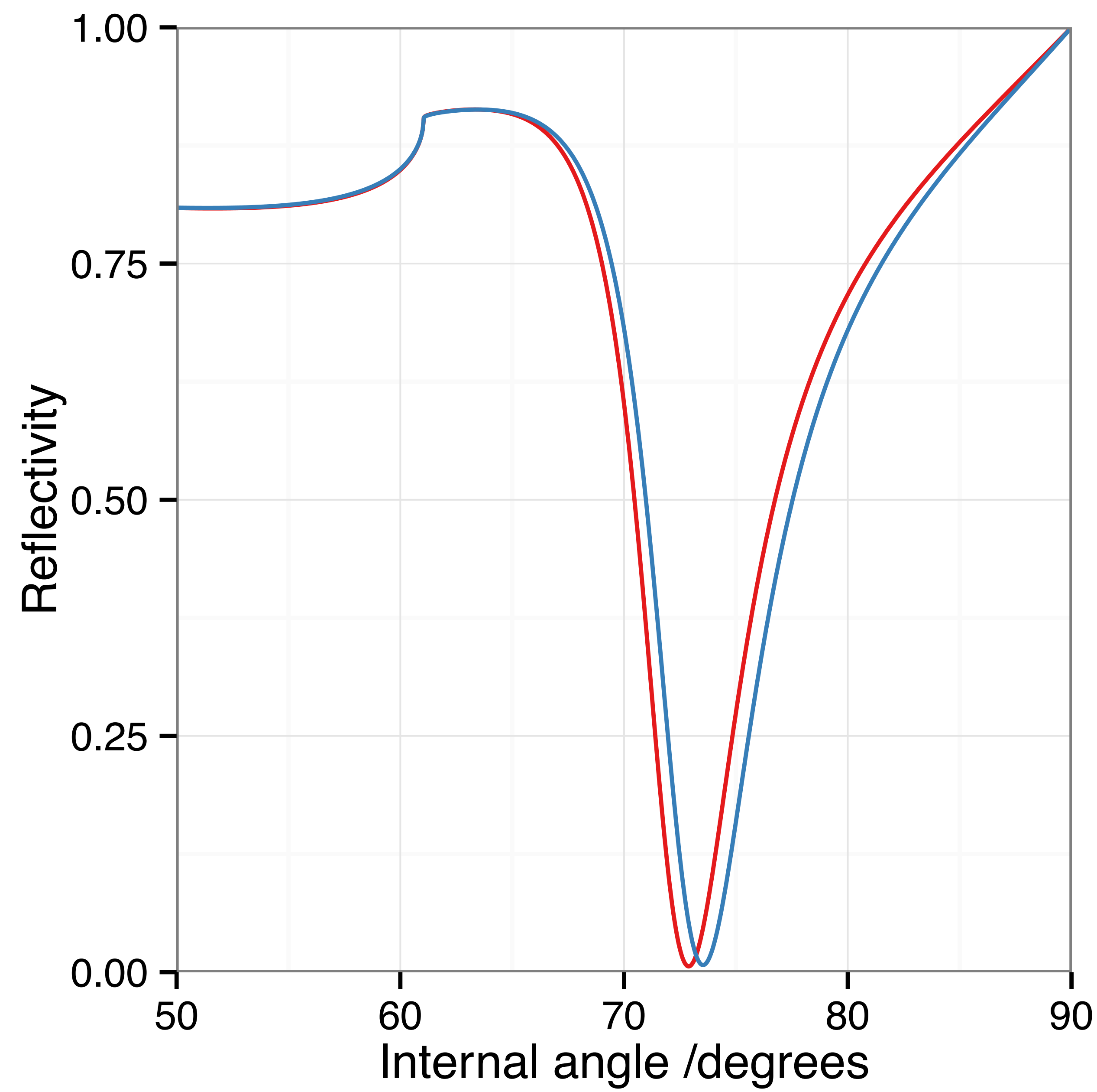


Promising refractive-index sensor?



Surface plasmon resonance sensing





Nature Reviews Drug Discovery 1, 515-528 (July 2002)

doi:10.1038/nrd838