Analysis of Surface Plasmon Resonance

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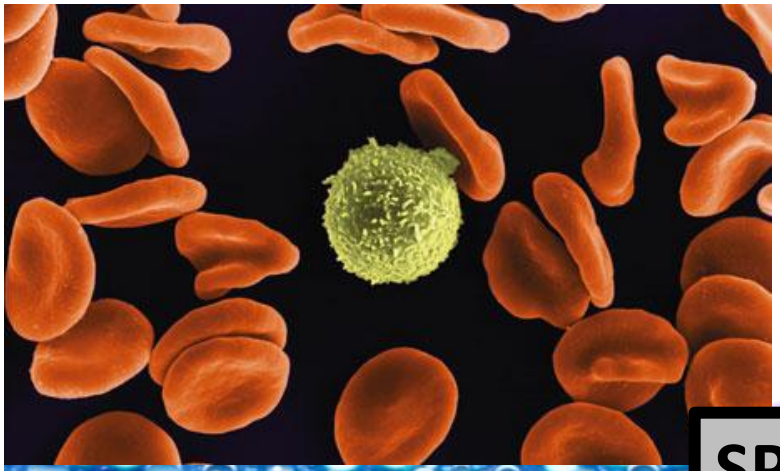
COMSOL Conference: October 3-5, 2012

Surface Plasmon Resonance

Life Science



Vapor Detection

SPR

Surface Coatings

Environmental Safety

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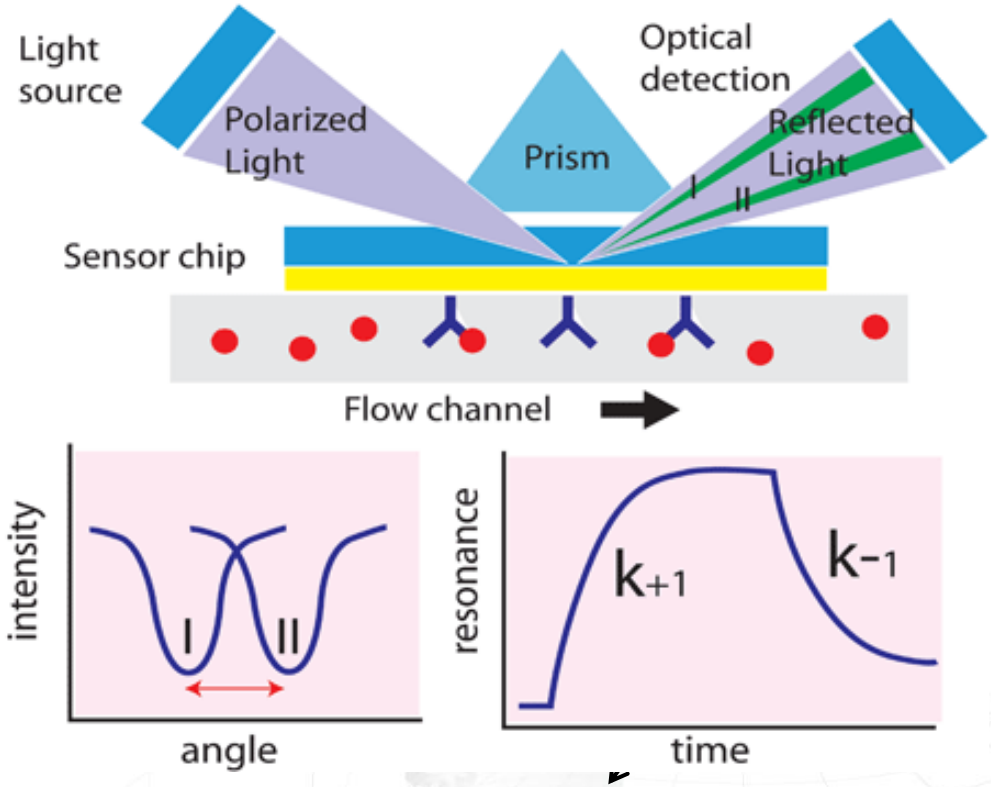
Surface Plasmon Resonance



Component of scattering vector parallel to surface produces surface plasmon

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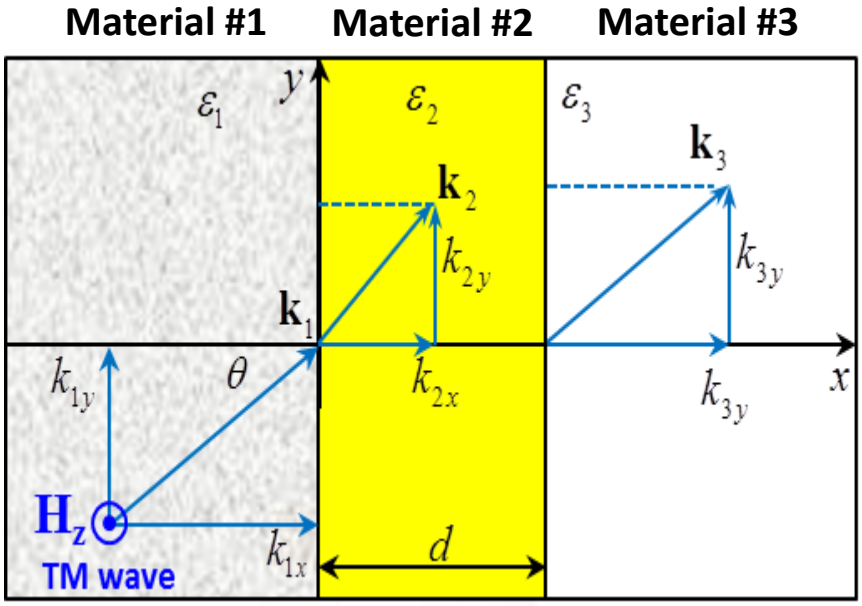
SPR Problem Description



Incident transverse magnetic (TM)
Layer of thickness d and permittivity ε_2
Between two layers with permittivity ε_1 and ε_3

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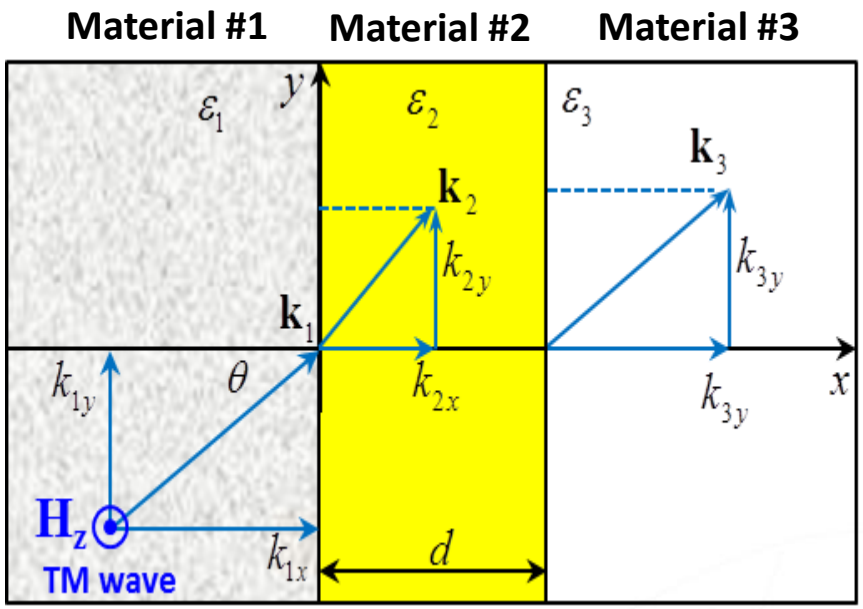
SPR Problem Set-up: Analytical



- **Transverse Magnetic wave reflection response:**

$$\Gamma = \frac{\rho_1 + \rho_2 e^{-2jk_{2x}d}}{1 + \rho_1 \rho_2 e^{-2jk_{2x}d}}$$

- **Wave vectors**
- **Evanescent wave propagation**

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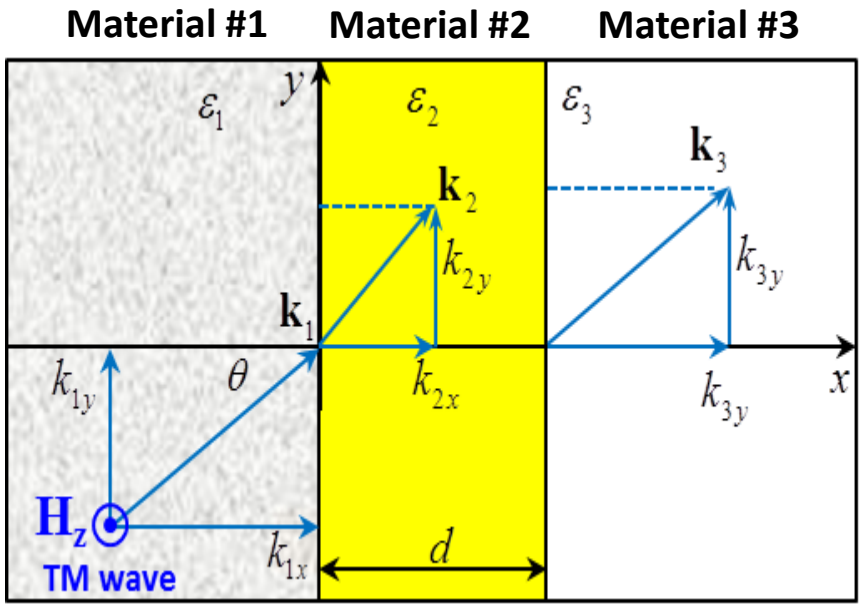
SPR Problem Set-up: COMSOL



Propagation using Maxwell's equation:

$$\nabla \times \frac{1}{\mu_r}(\nabla \times \mathbf{E}) - k_0^2\left(\varepsilon_r - \frac{j\sigma}{\omega\varepsilon_0}\right)\mathbf{E} = 0$$

- **Floquet BCs on surfaces of the layers**
  - **Electric field symmetry**
  - **Phase shift**
- **Wave vectors**
- **Incident wave**
  - **Active port BC**
- **Exit wave**
  - **Passive port BC**
  - **Transmission without reflection**

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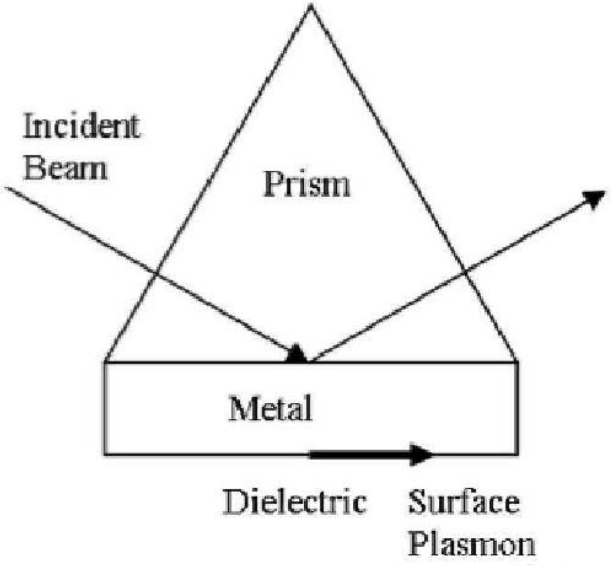
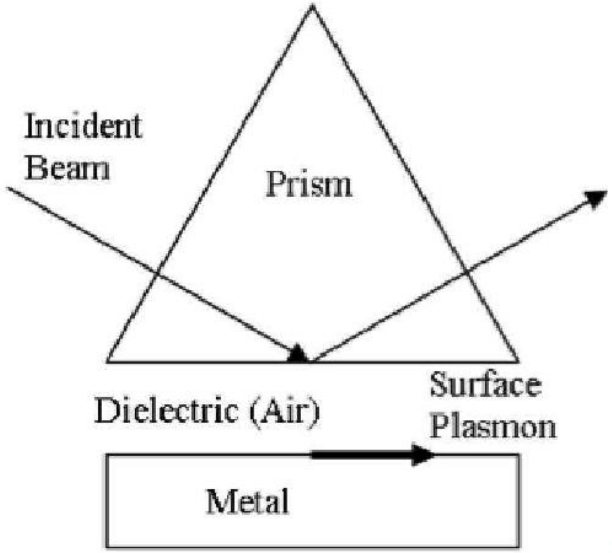
SPR: Application

- **Kretschmann-Raether**



- **Otto**



Parameter	K-R	Otto
ε_1	2.25 (Quartz)	2.25 (Quartz)
ε_2	-16-0.5j (Silver)	1 (Air)
d	50 nm	1000 nm
ε_3	1 (Air)	-16-0.5j (Silver)

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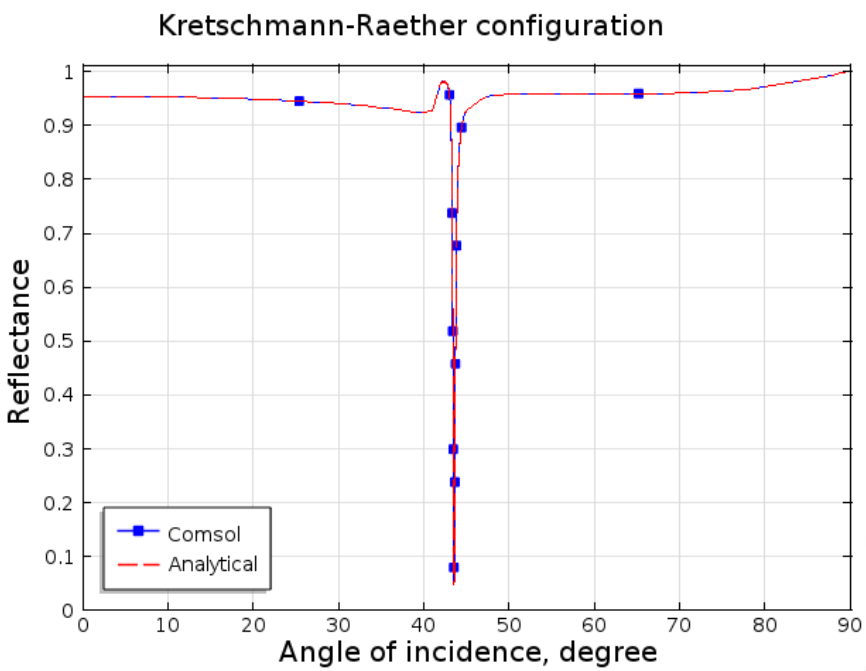
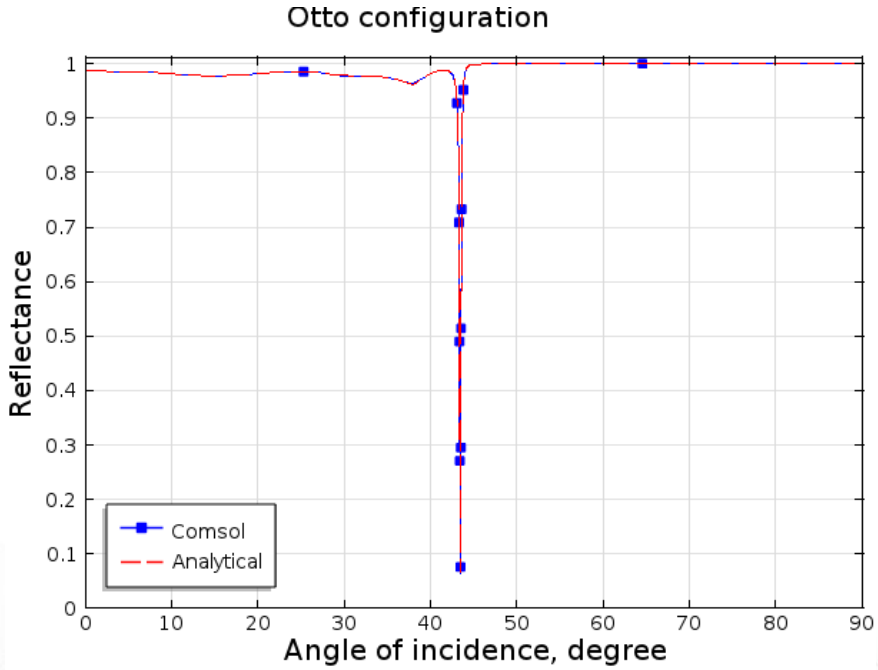
SPR - Results





Agreement between analytical and computational solution

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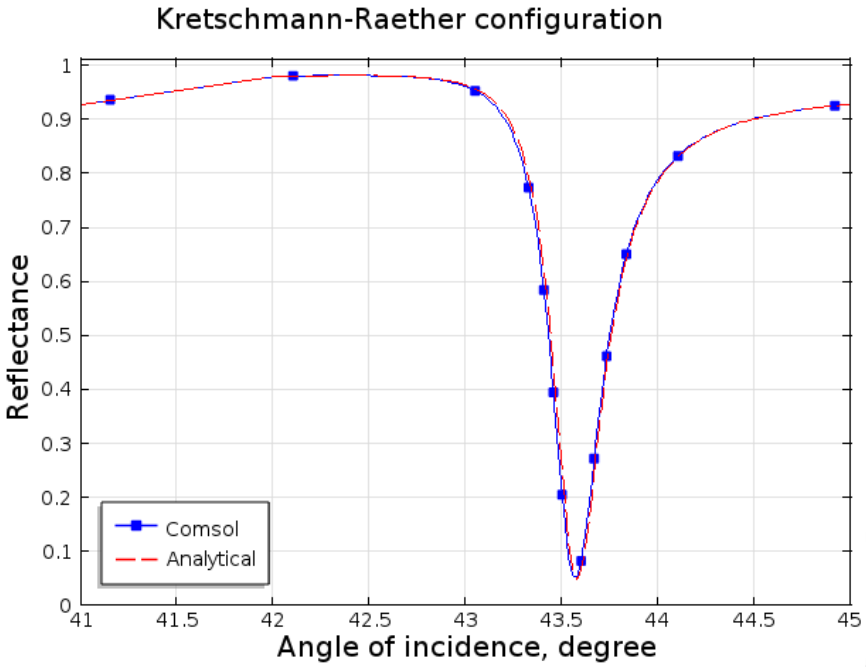
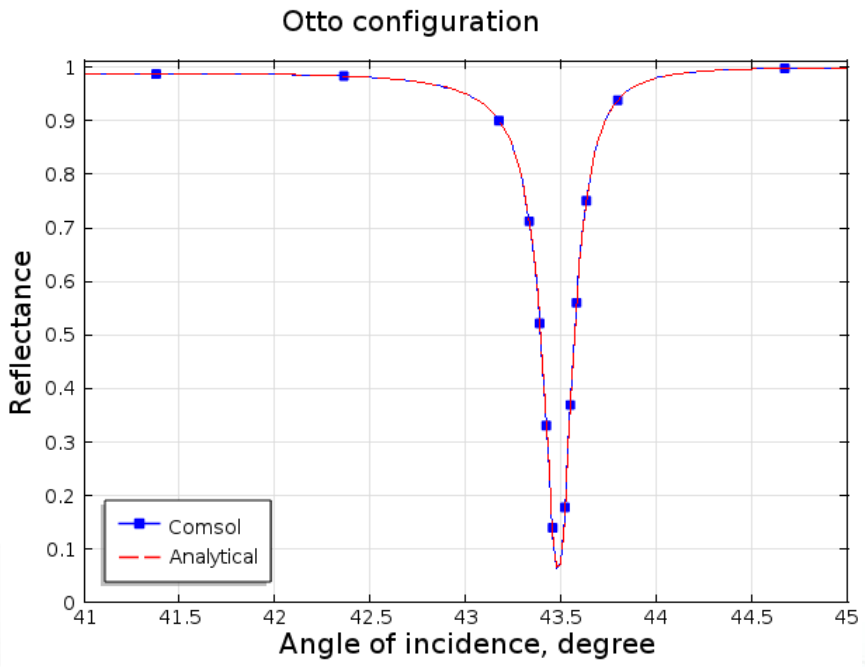
SPR - Results





Θ_{SPR}= 43.58°

Θ_{SPR}= 43.49°

Difference in Θ_{SPR} for K-R and Otto
Θ_{SPR} sensitive to ε_2

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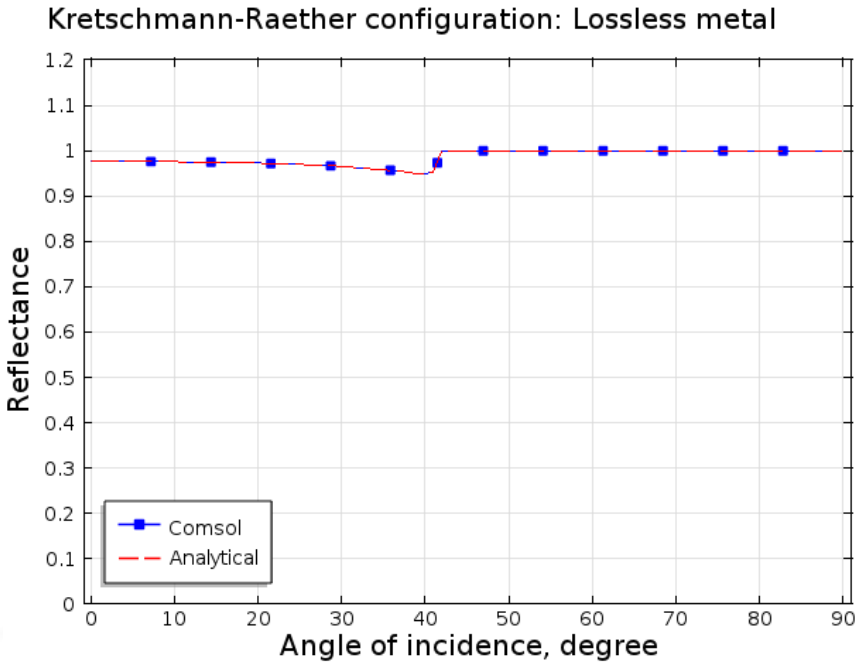
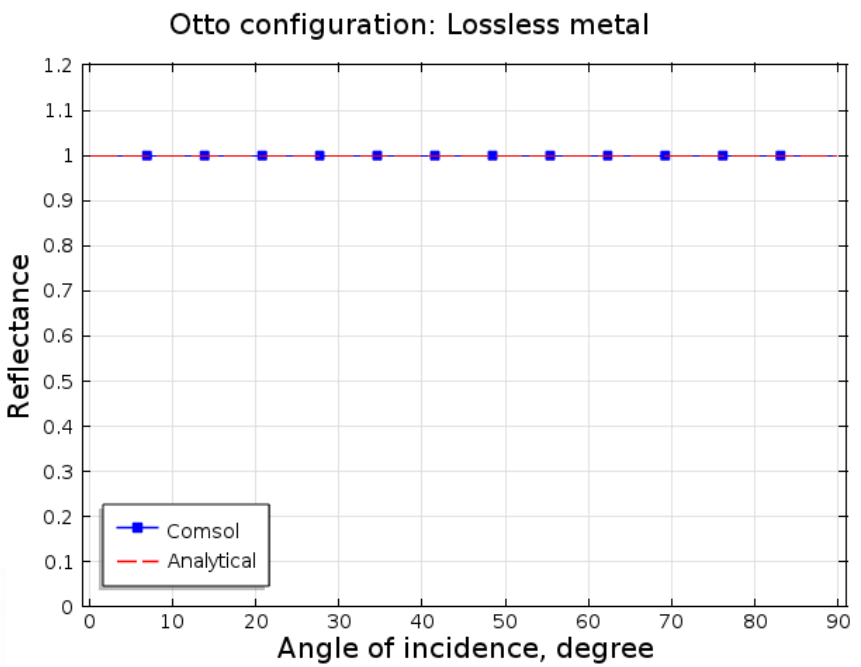
SPR - Results

Kretschmann-Raether



Otto



Metal must be "lossy" to excite plasmon resonance
K-R: Evanescent wave below the critical angle
K-R: TIR at, and above, the critical angle
Otto: Total internal reflection for all incidence angles

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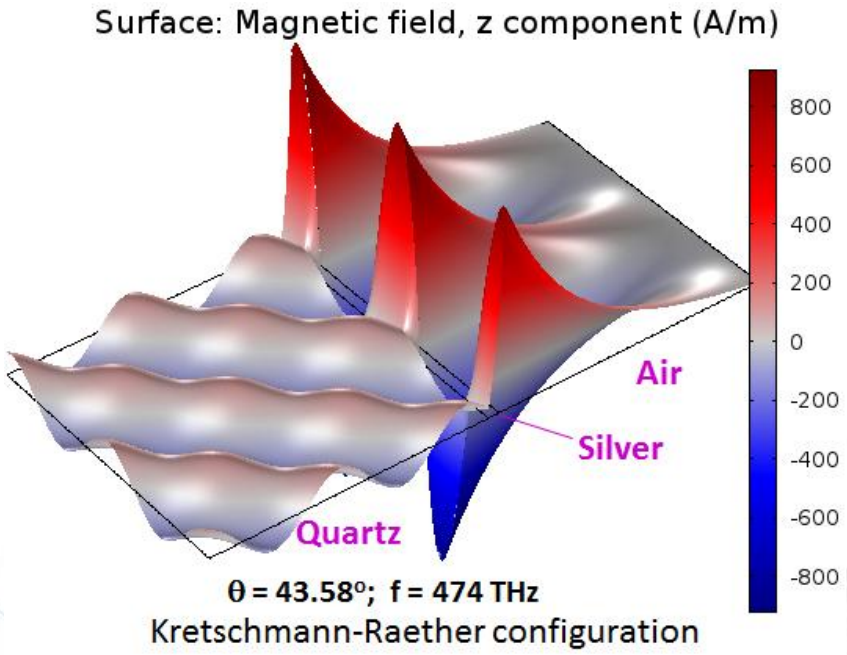
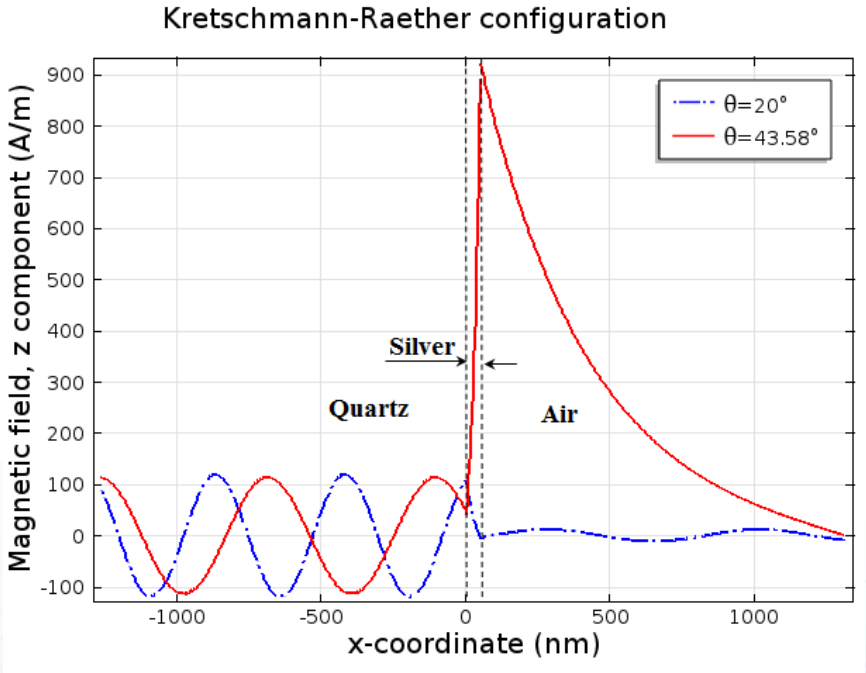
SPR - Results

Magnetic field distribution at resonance: Kretschmann-Raether





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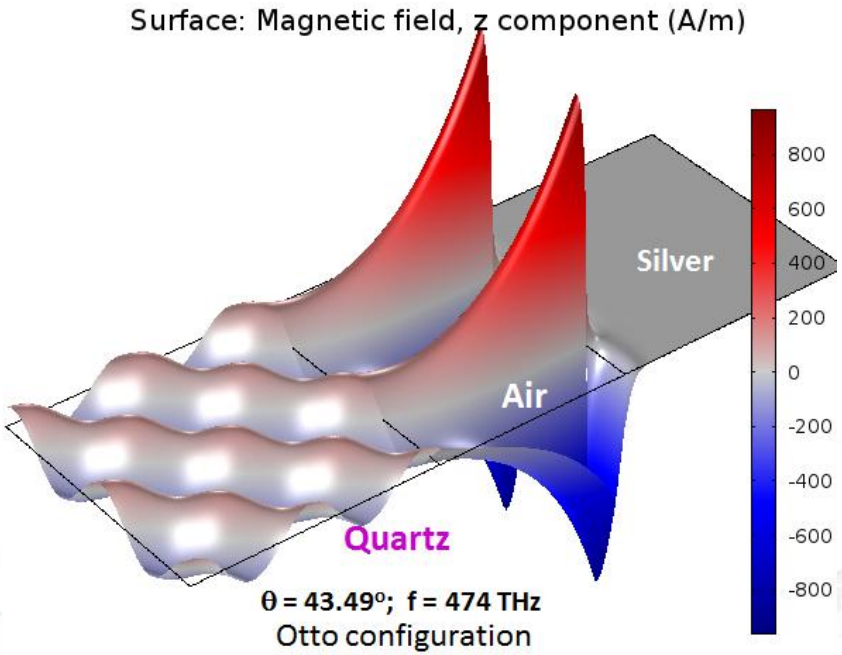
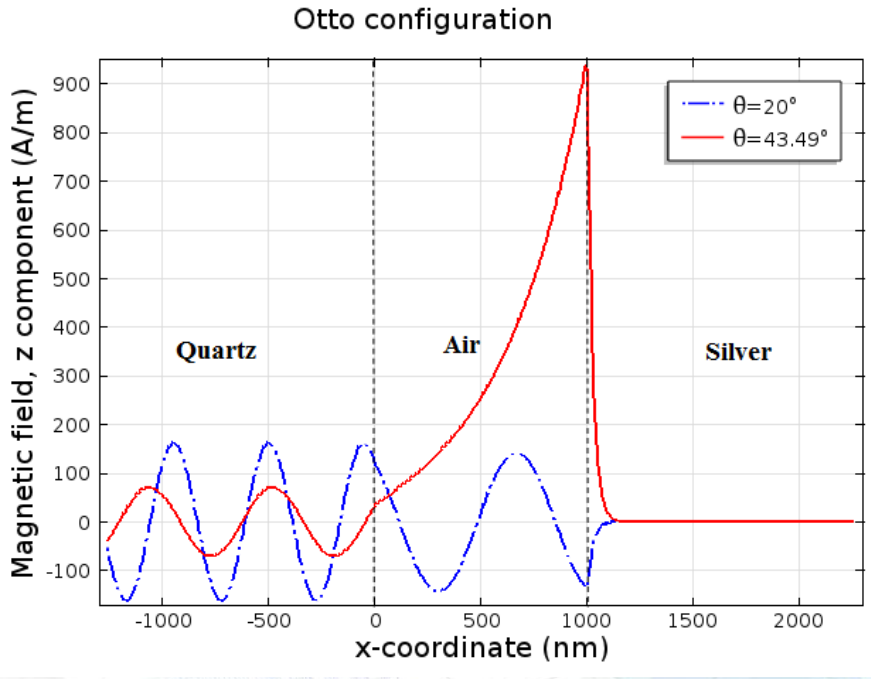
SPR - Results

Magnetic field distribution at resonance: Otto





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Surface Plasmon Resonance Summary

- Implementation of SPR in COMSOL demonstrated
- Two most common configurations analyzed
- Effect of permittivity documented
- Tool for application