A Study on the Suitability of Indium Nitride for Terahertz Plasmonics

Arjun Shetty[1], K J Vinoy[1], S B Krupanidhi[2]
1. Electrical Communication Engineering, Indian Institute of Science, Bangalore, India;
2. Materials Research Centre, Indian Institute of Science, Bangalore, India.

Introduction: Interest in plasmonic phenomena has extended beyond the visible spectrum [1] This shift has led to a search for new materials that have a plasma frequency more suited to UV or THz frequencies[2]. Plasmonic resonances in Au and InN are studied at f = 10THz, and their performances are compared.

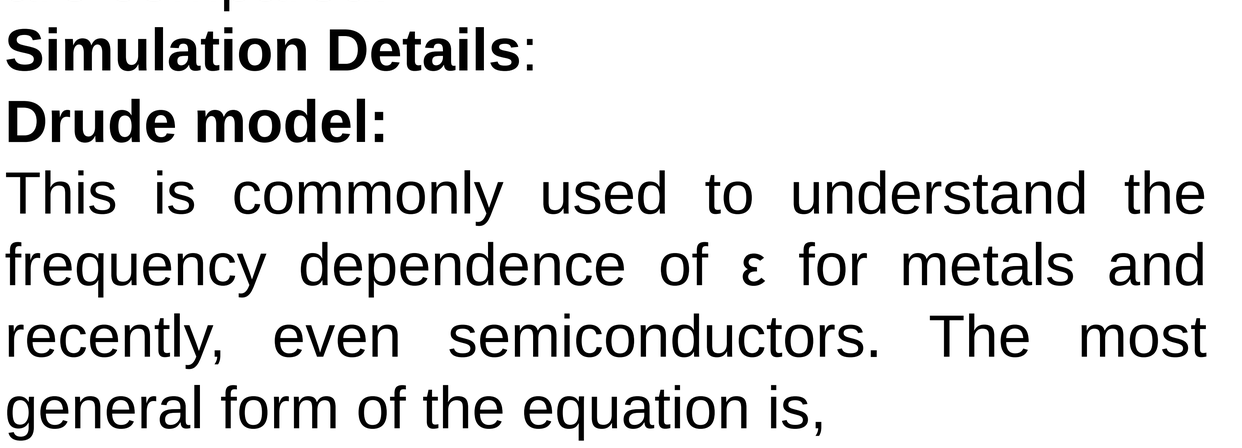
Simulation Details:

Drude model:

This is commonly used to understand the frequency dependence of ε for metals and recently, even semiconductors. The most general form of the equation is,

$$\varepsilon(\omega) = \varepsilon_\infty - \frac{\omega_p^2}{\omega^2 + i\gamma\omega}$$

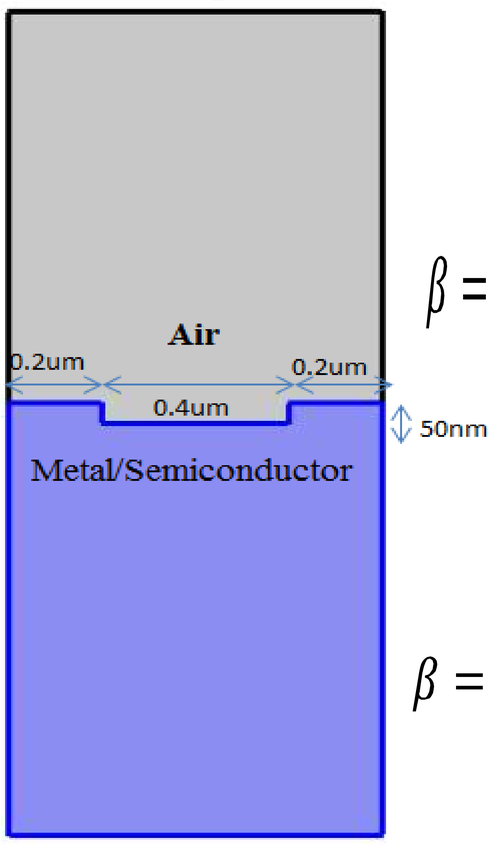
ε_∞ -> dielectric constant at high frequency
$\omega_p = 2\pi f$ -> plasma frequency
$\Gamma = 1/\tau$ -> damping factor
τ -> relaxation time of the free electron gas
Values used:
Au (ε_∞= 9.2, f_p = 2.18x10^{15}Hz, γ = 6.46x10^{12}s^{-1}) [4]
InN (ε_∞ = 6.7, f_p = 52x10^{12}Hz, τ = 52x10^{-15}s) [5]



(a) (b)

Figure 1. Relative permittivity of (a) Au and (b) InN

Geometry:



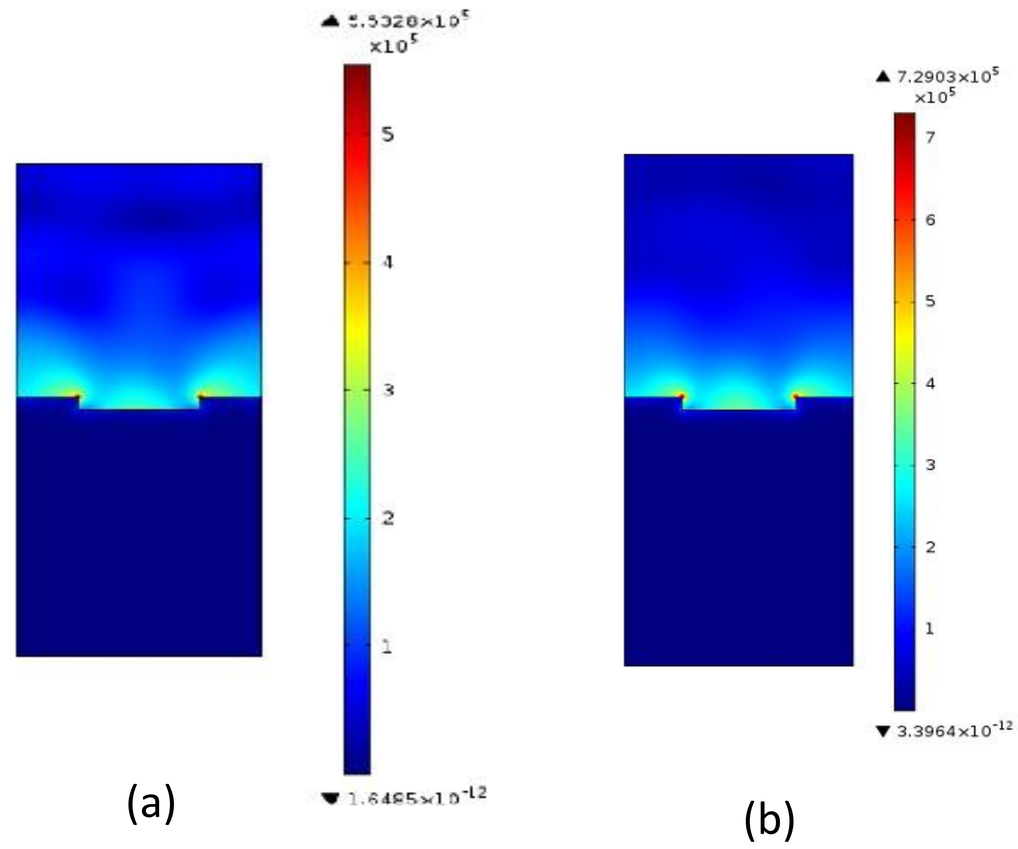
$$\beta = k_0 \sqrt{\frac{\varepsilon_1 \varepsilon_2}{\varepsilon_1 + \varepsilon_2}}$$

β -> propagation constant of surface wave
k0 -> wave vector of free space wave
ε1, ε2 -> permittivities of air and grating material
g = 2π/a -> reciprocal vector of the grating
a -> grating periodicity
θ -> angle of incidence

$$\beta = k_0 \sin\theta \pm \nu g$$

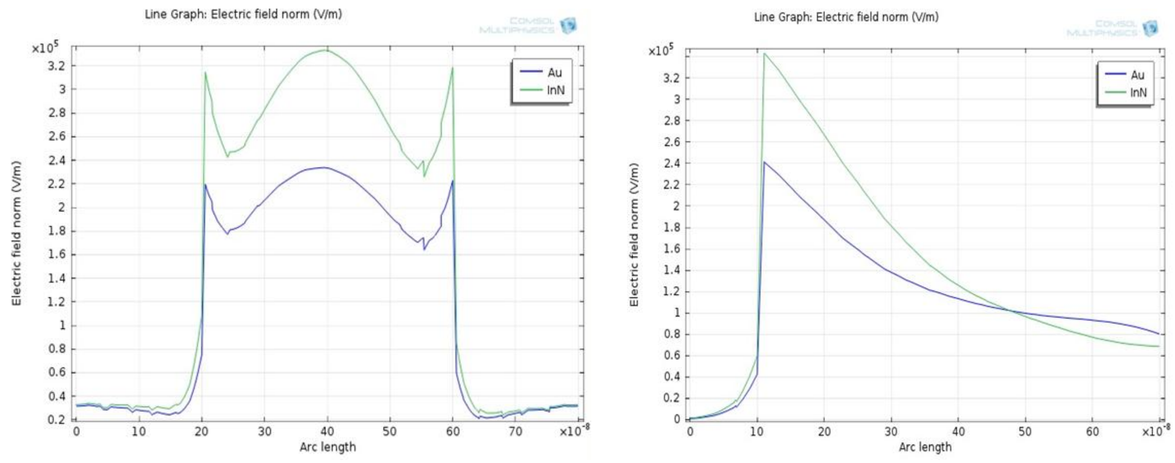
Figure 2. Grating Geometry

Results:



(a) (b)

Figure 3. Electric field distribution in gratings (a) Au and (b) InN



(a) (b)

Figure 4. Field distribution (a) within grating and (b) as a function of distance from interface

Conclusions: Results indicate greater field enhancement (upto 1.4 times) for the case of InN gratings as compared to Au gratings. These results indicate that InN shows substantial potential as an alternative plasmonic material to metals in the IR and THz range.

References:

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