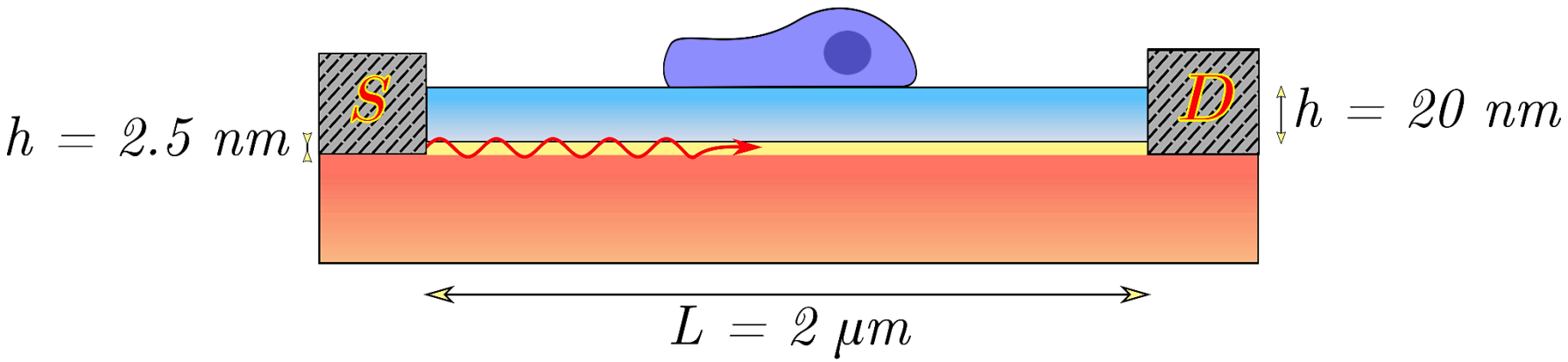
Plasma based High resolution microscopy

4-6-2017

Structure Details



$Al_{.2}Ga_{.8}As$

2DEG

GaAs

Electrical Properties of 2DEG

- Thin sheet of charge
- Charge density depending on heterostructure materials
- Mobility is temperature dependent

$$N \sim 10^{11} - 10^{14} [cm^{-2}]$$

$$\mu_{4K} \sim 10^{6} \left[\frac{V}{cm^2 s}\right]$$

$$\mu_{295K} \sim 10^{3} \left[\frac{V}{cm^2 s}\right]$$

$$\tau = \frac{\mu\, m^*}{e} \propto \frac{1}{T^{1.5}}$$

$$\sigma_s(\omega) = \frac{N\, e^2 \tau}{m^*} \frac{1}{1 - j\,\omega\tau}\ [S]$$

Dispersion Relation

$$Y_1 + Y_2 + Y_\sigma = 0$$

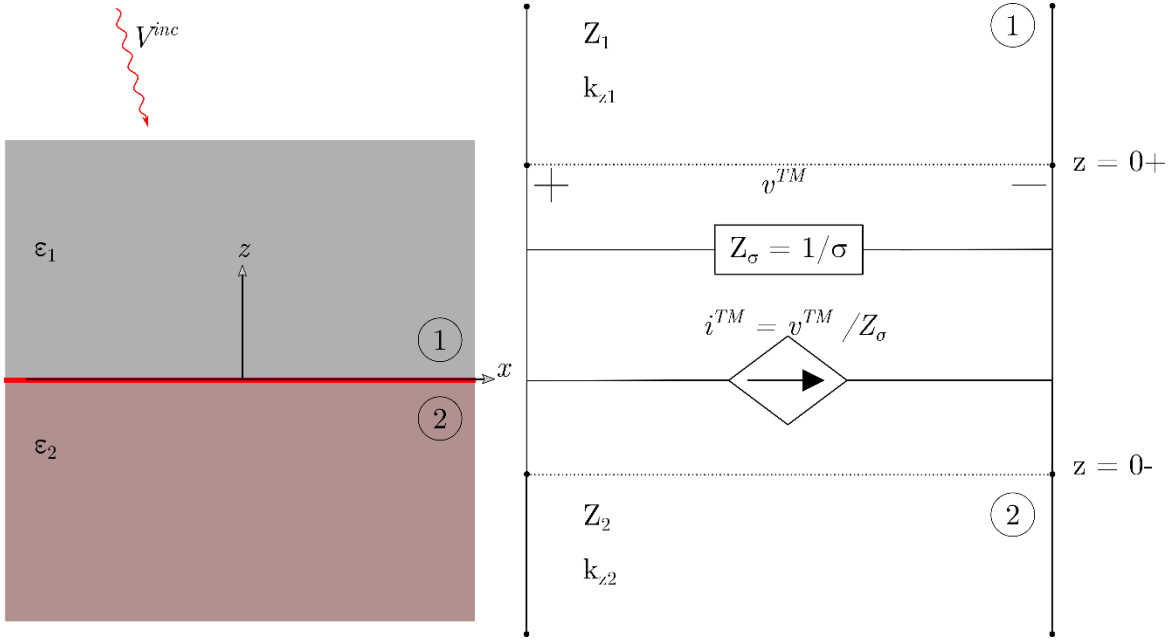
$$\frac{\varepsilon_1}{k_{z1}} + \frac{\varepsilon_2}{k_{z2}} = -\frac{\sigma_s(\omega)}{\omega\,\varepsilon_0}$$

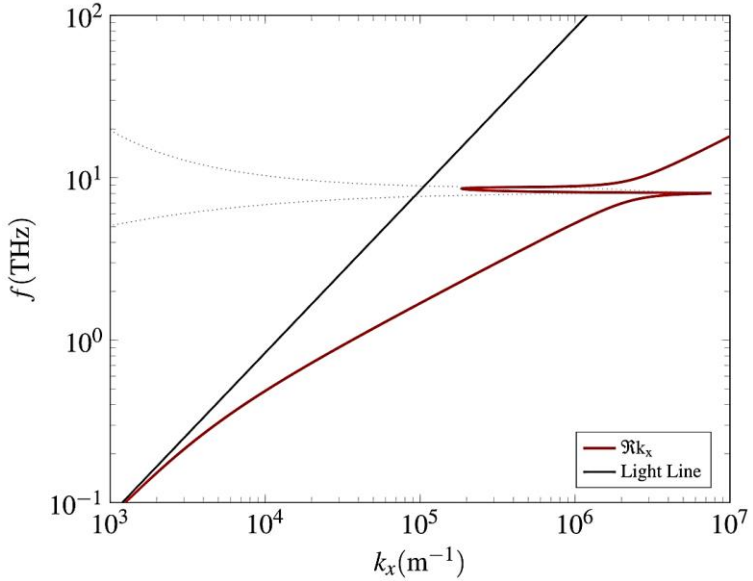
$$Y_i = \frac{1}{Z_i} = \frac{\omega\varepsilon_i}{k_{zi}}$$

$$k_{zi} = \pm\sqrt{\left(\frac{\omega}{c}\right)^2 \varepsilon_i - k_x^2}$$

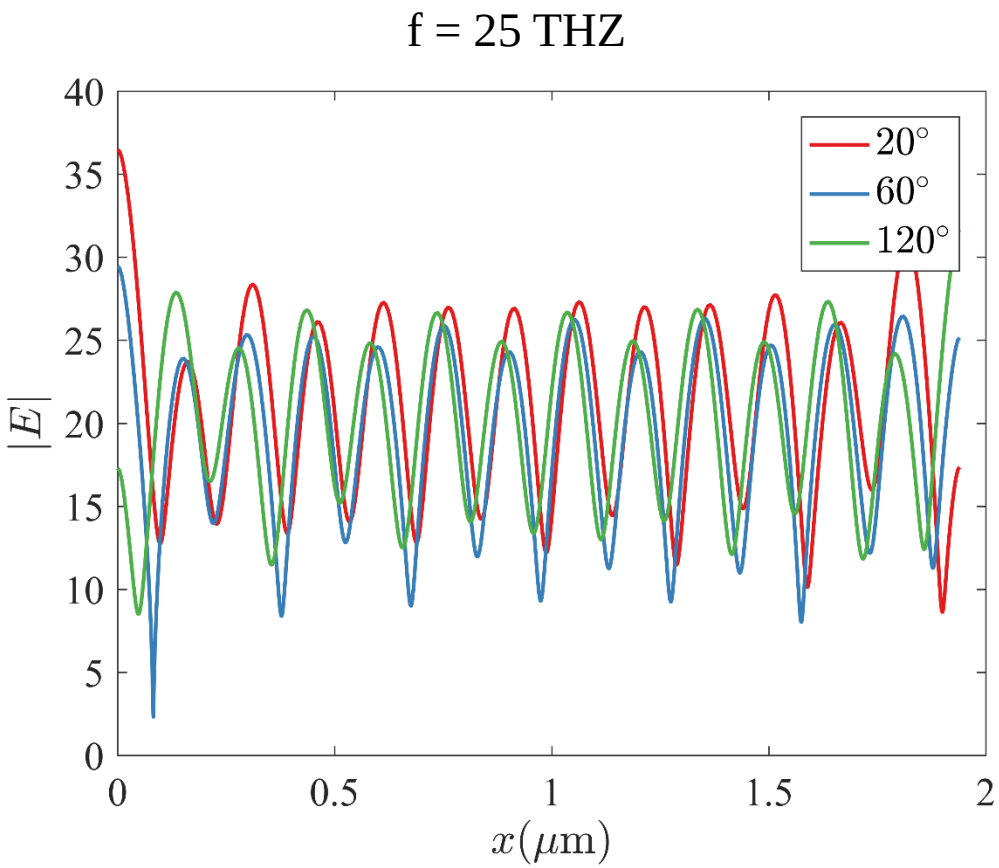
$$Y_\sigma = \frac{1}{Z_\sigma} = \sigma_s$$

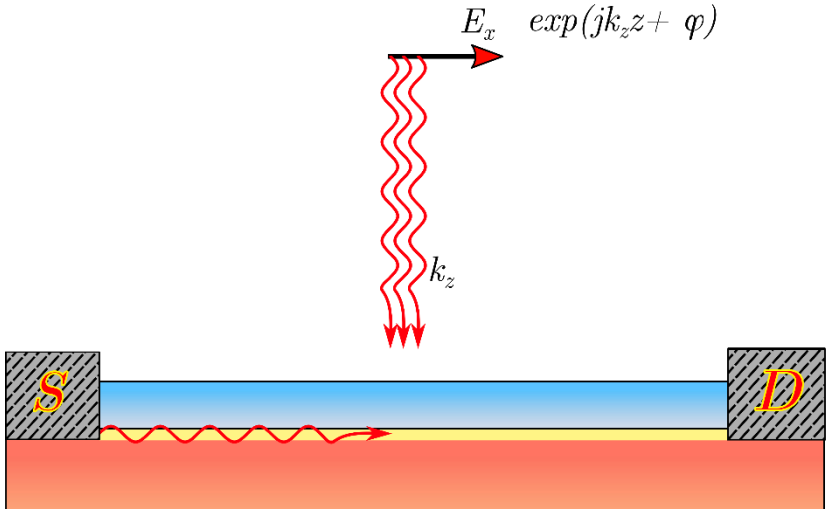
$$k_x \approx (\varepsilon_1 + \varepsilon_2)\frac{\omega}{\sigma_s}$$





Shifting of standing wave





Standing wave pattern with shifting phase of incident TM wave

COMSOL Simulation

- 2DEG modeled as d = 2.5 nm thin slab
  - Surface current used to model surface charge
  - Small negative real part and vanishing imaginary part (close to plasma frequency)

$$\varepsilon_{2deg} = \varepsilon_{GaAs} + j\frac{\sigma_s(\omega)}{\omega d\, \varepsilon_0}$$

  - $\varepsilon_{GaAs} = 11$, $\varepsilon_{AlGaAs} = 10.7$