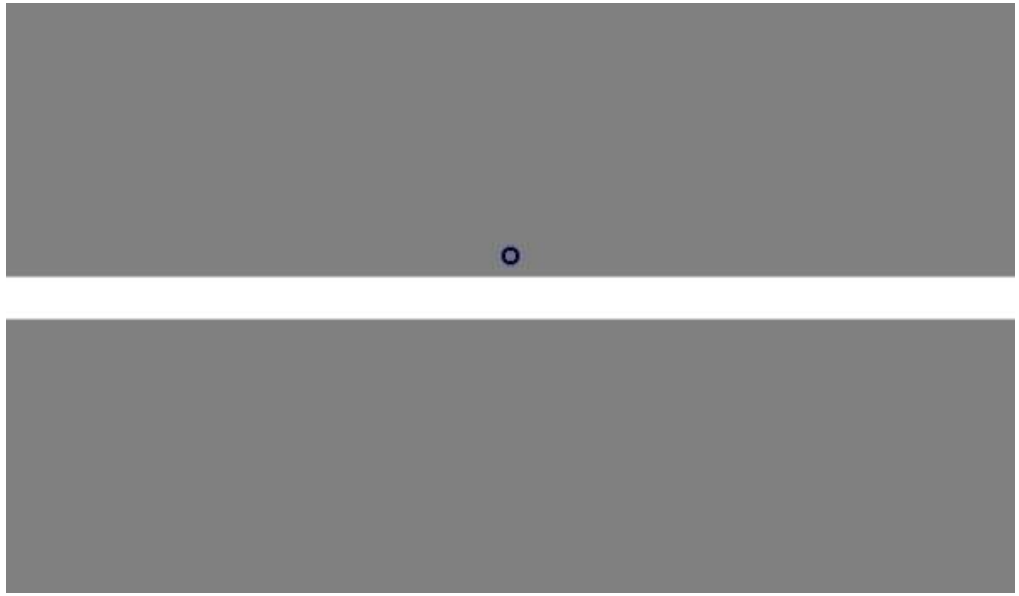
Surface Plasmon Resonance



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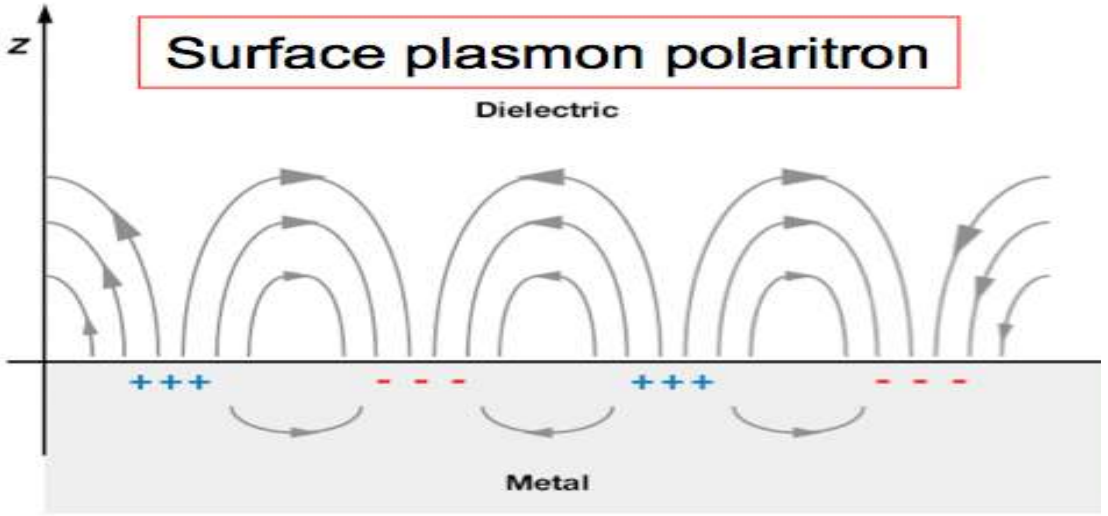
Presentation Outline

- Theory
- Realization
- Experimental Results
- Computational Simulations
- Applications of SPR Devices

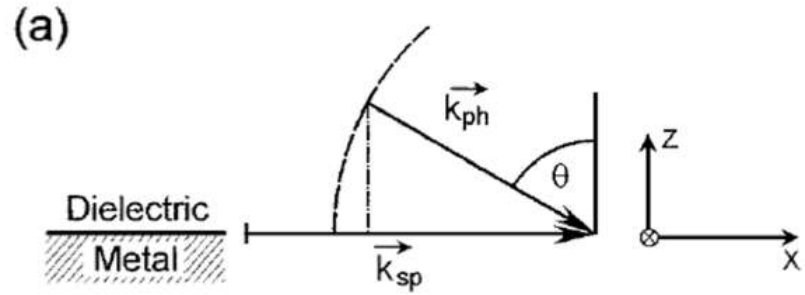
Theory

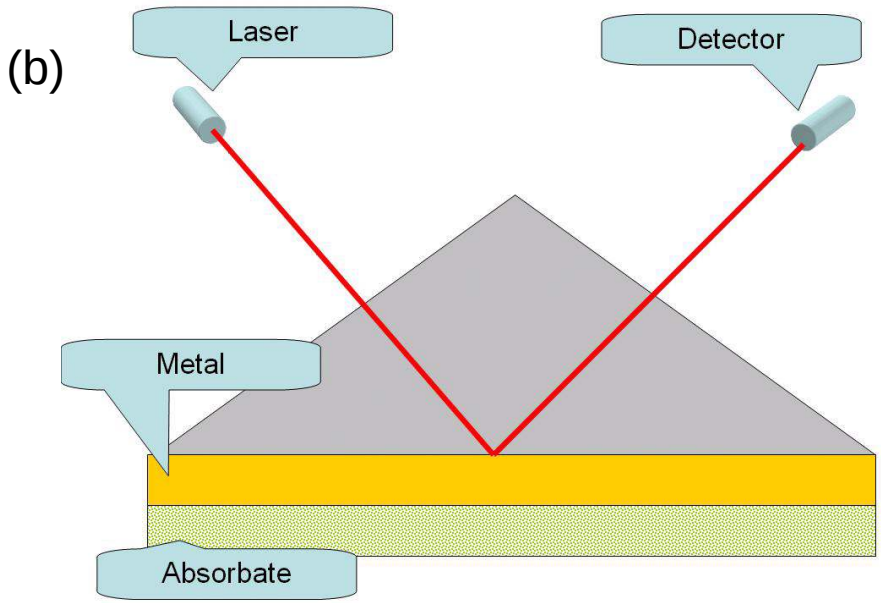


- Surface Plasmon Polaritons (SPP's) are EM excitation states coupled to collective oscillations of the free electron gas density to within the metal.
- Direction of travel is transverse to the metallic surface.
- Intensity decays exponentially with increasing distance from interface.

Realization

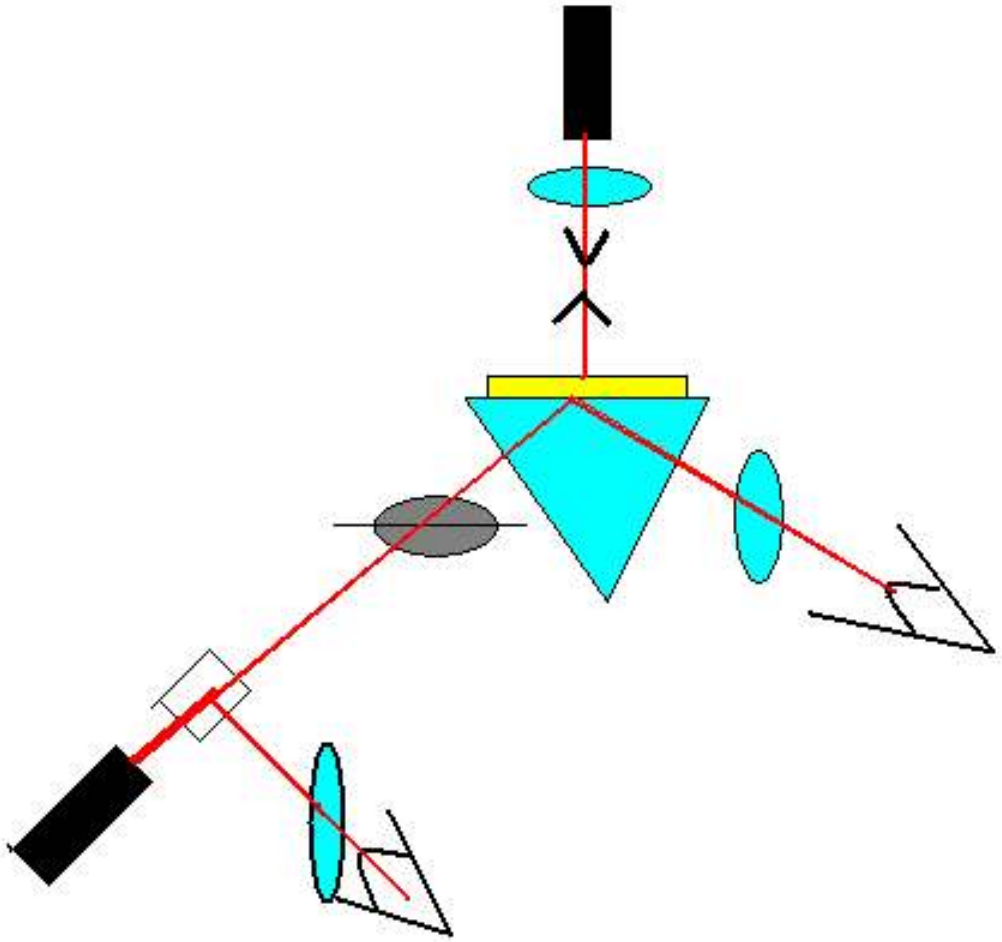
- Usually generated by incoming light or electron beam.
- Transverse component of incoming breams wave vector must match that of the plasmon, and their wavelengths must match as well (Figure a).
- The following dispersion relations apply to the incoming wave and plasmon wave respectively:



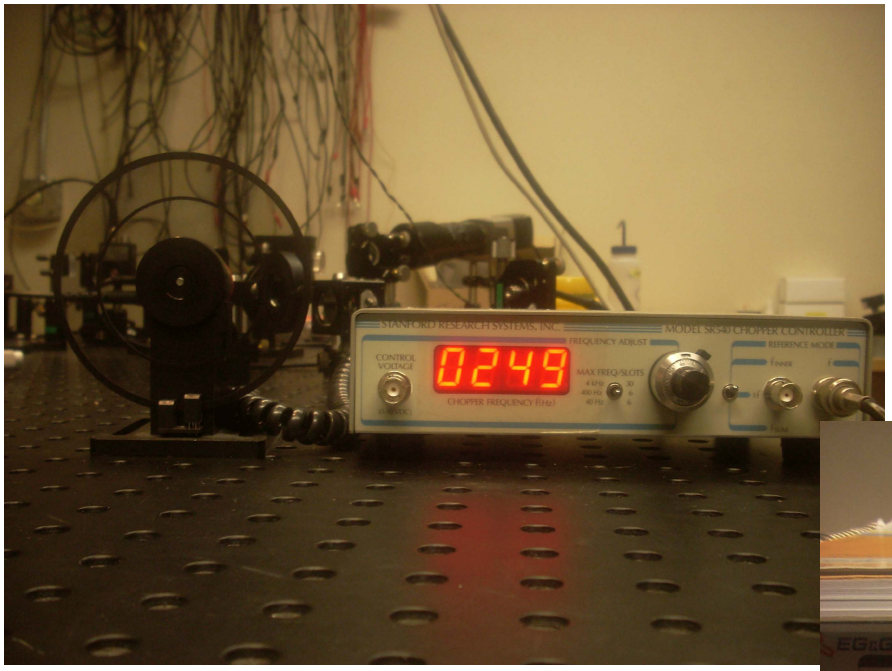


- These conditions cannot be met for light falling directly on interface.
- Instead, a prism must be used to increase wave vector of incident beam (Figure b)

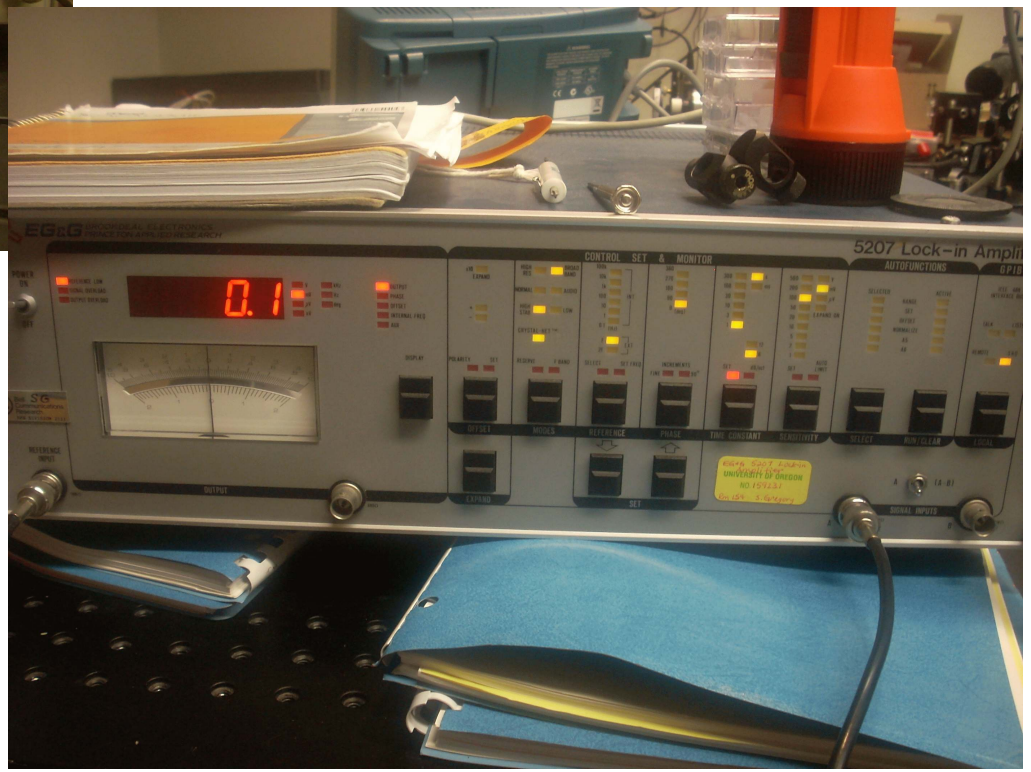
Experimental Set Up



Equipment

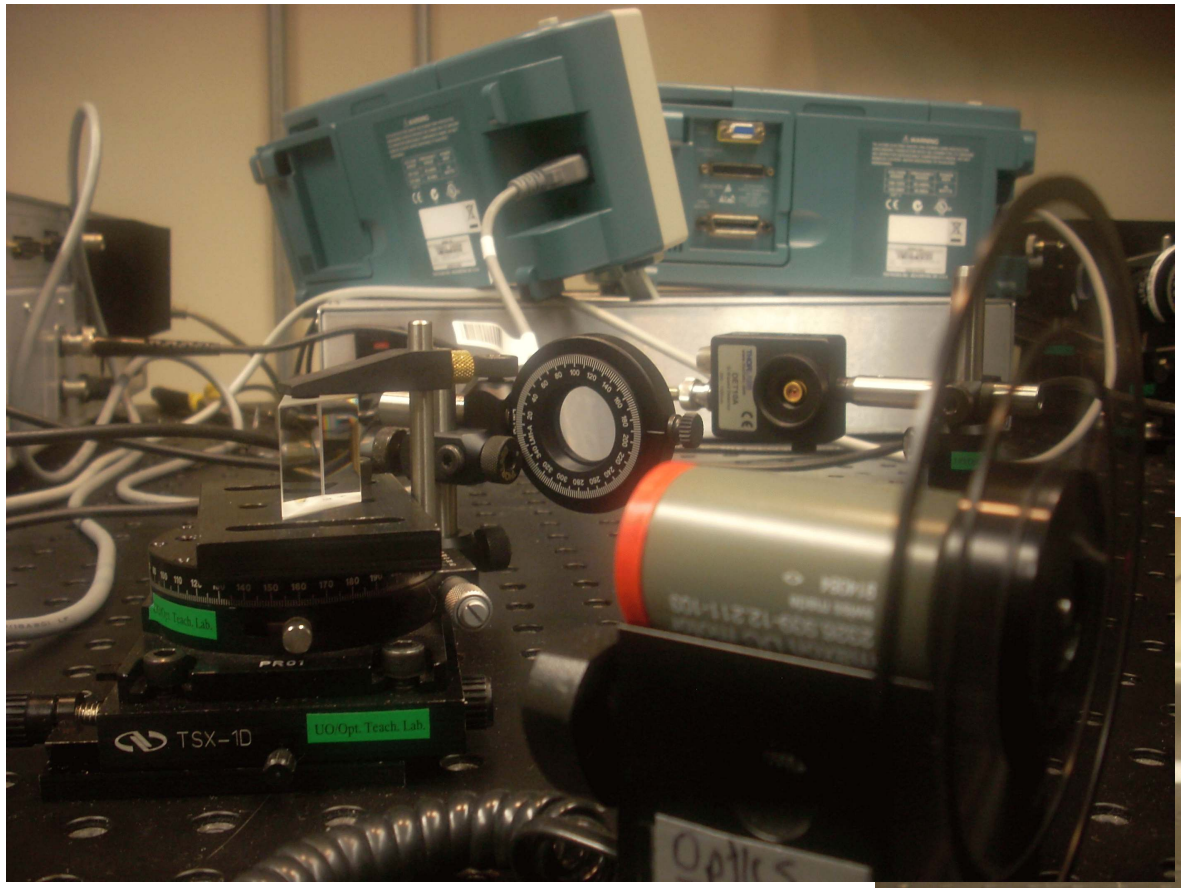


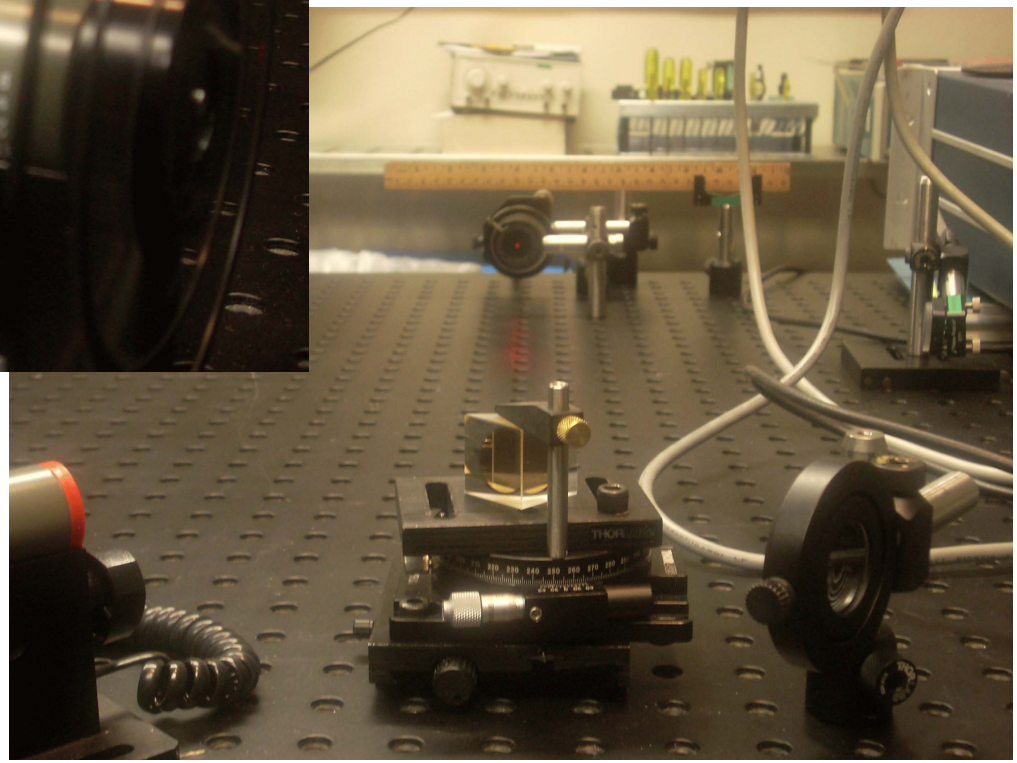
Optical chopper



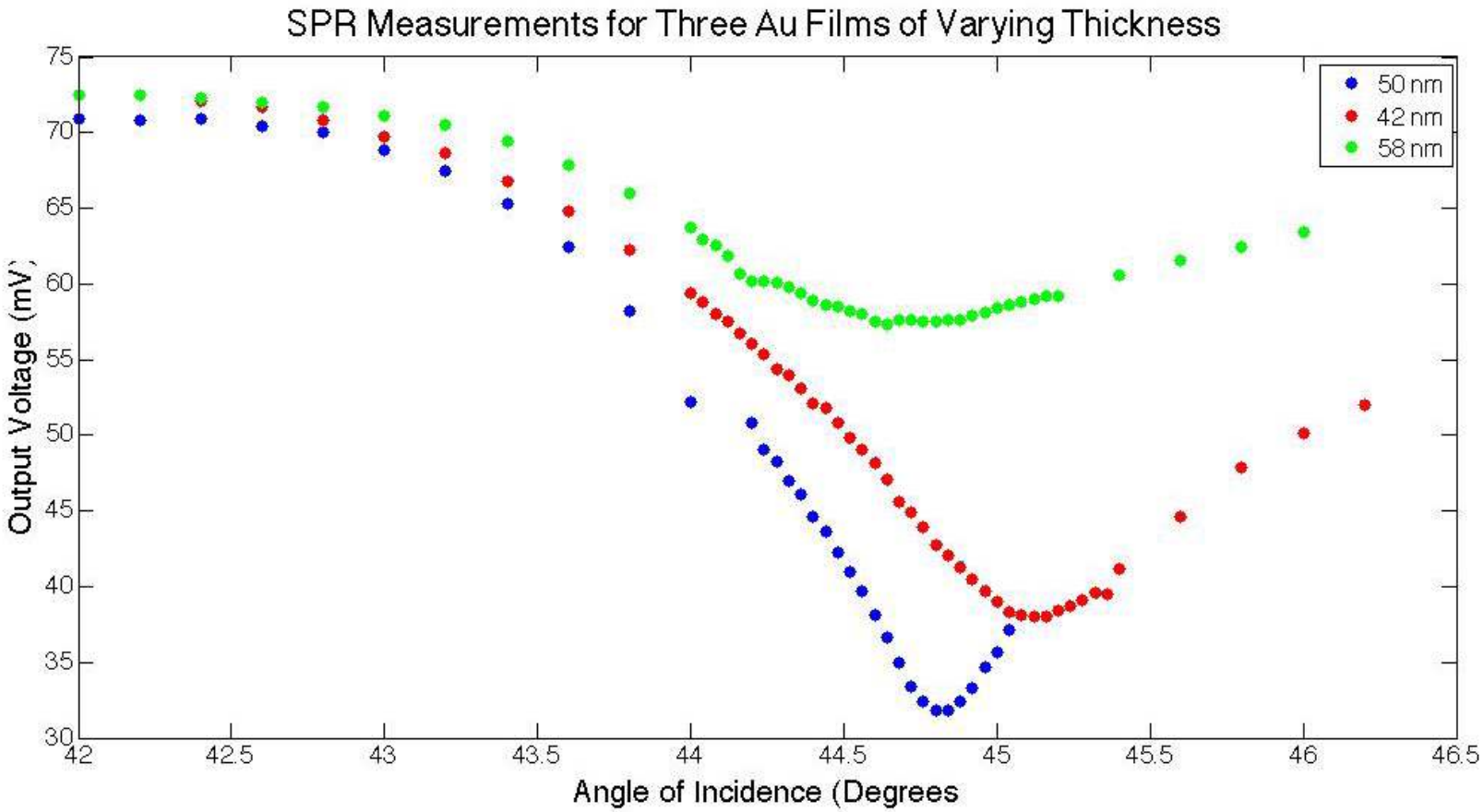
Lock-in amplifier

Optical Components



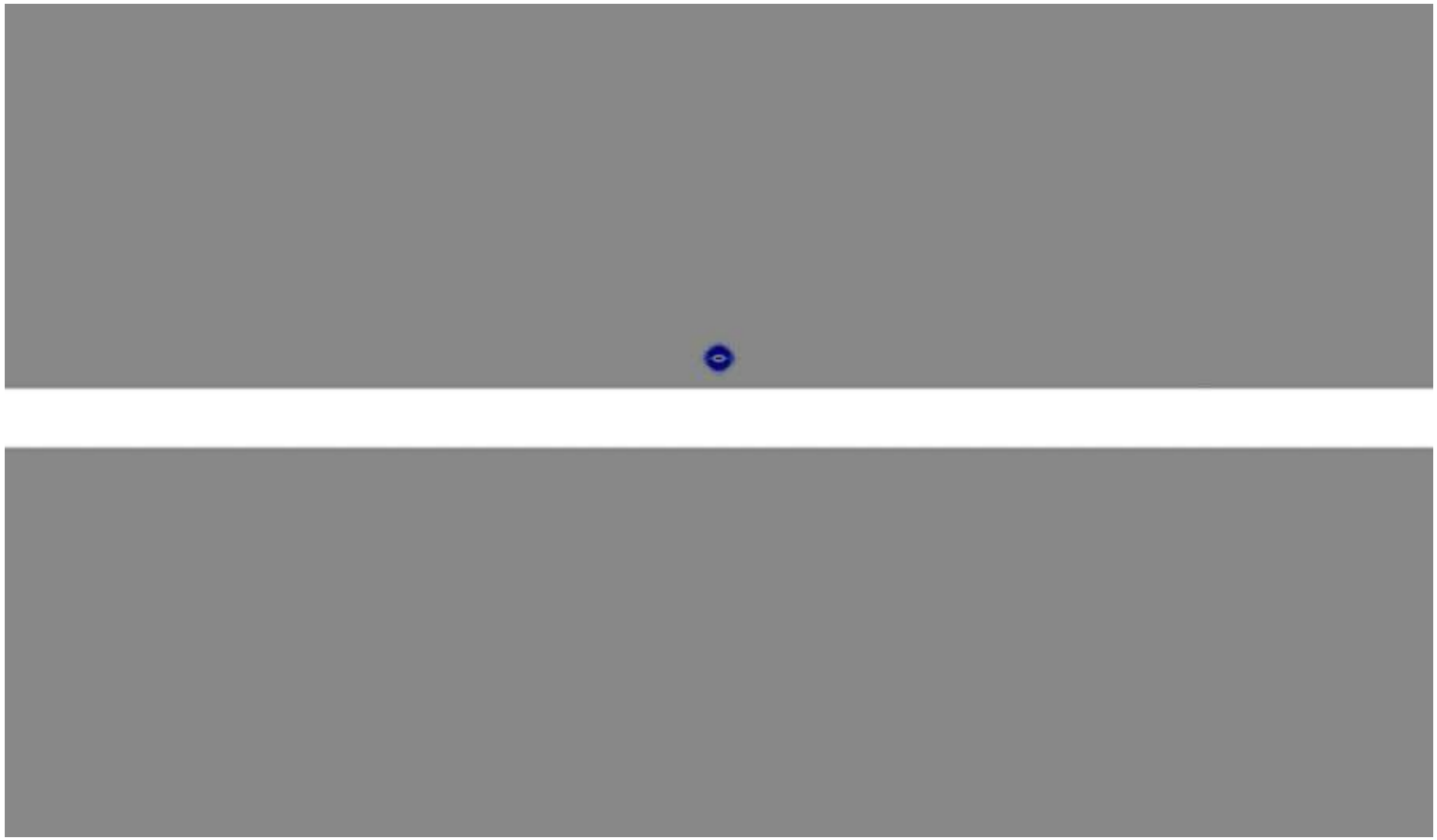


Results


SPR Measurements for Three Au Films of Varying Thickness
Output Voltage (mV)
Angle of Incidence (Degrees
50 nm
42 nm
58 nm
75
70
65
60
55
50
45
40
35
30
42
42.5
43
43.5
44
44.5
45
45.5
46
46.5

Computational Simulations

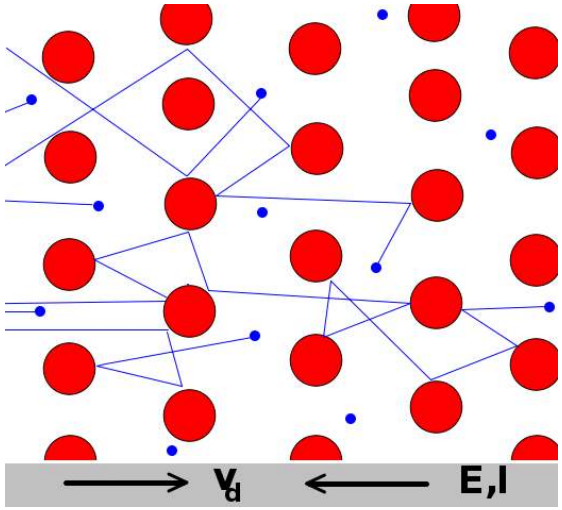
- Performed simulations using MEEP: a finite difference time domain (FDTD) software package for modeling EM systems.
- Primary challenge was modeling metals:
  - Negative real values of epsilon lead to instability in high frequency range.
  - This is because negative, frequency-independent real components of epsilon are nonphysical: MUST have dispersion.

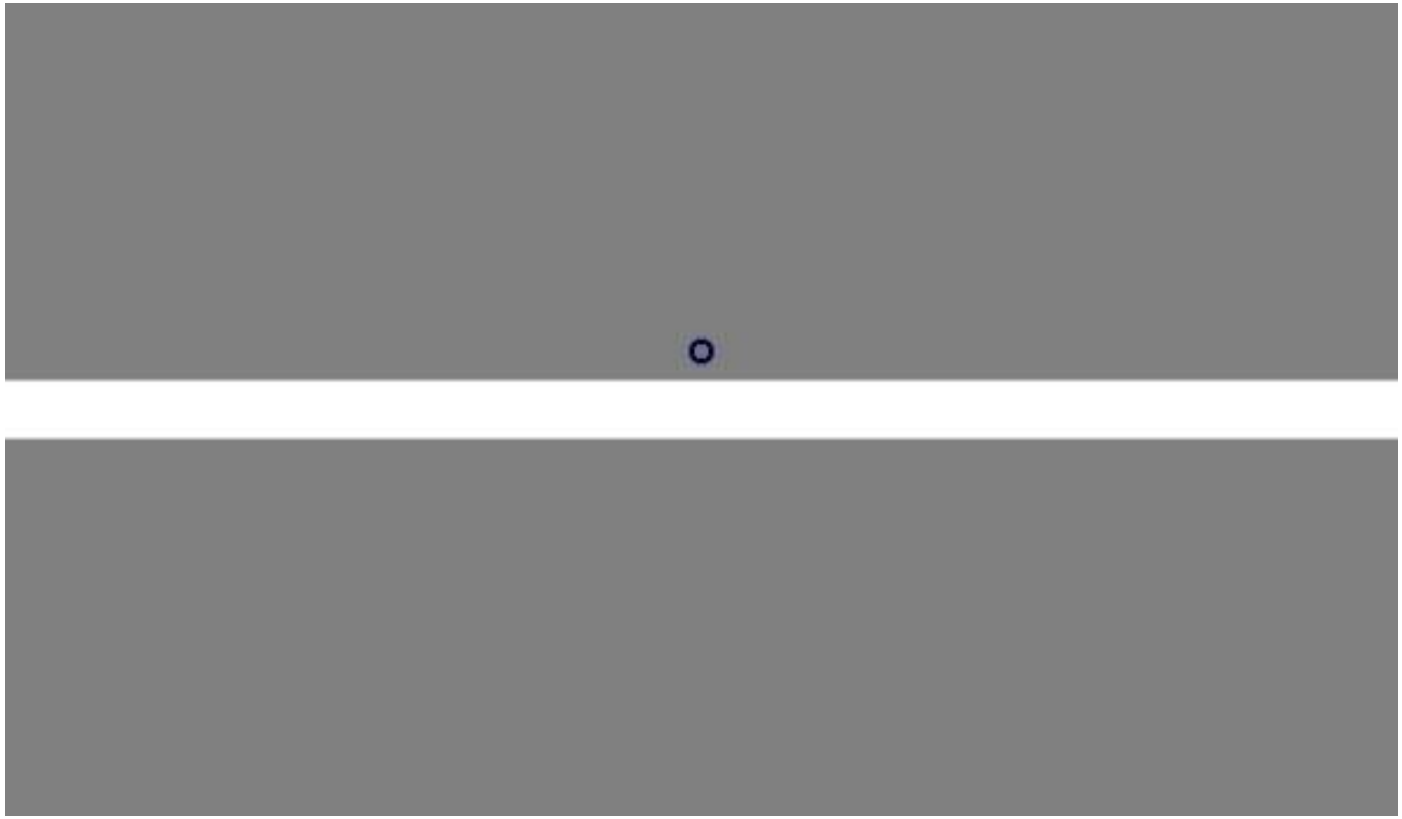


Ag interface defined via
exhibits instability.

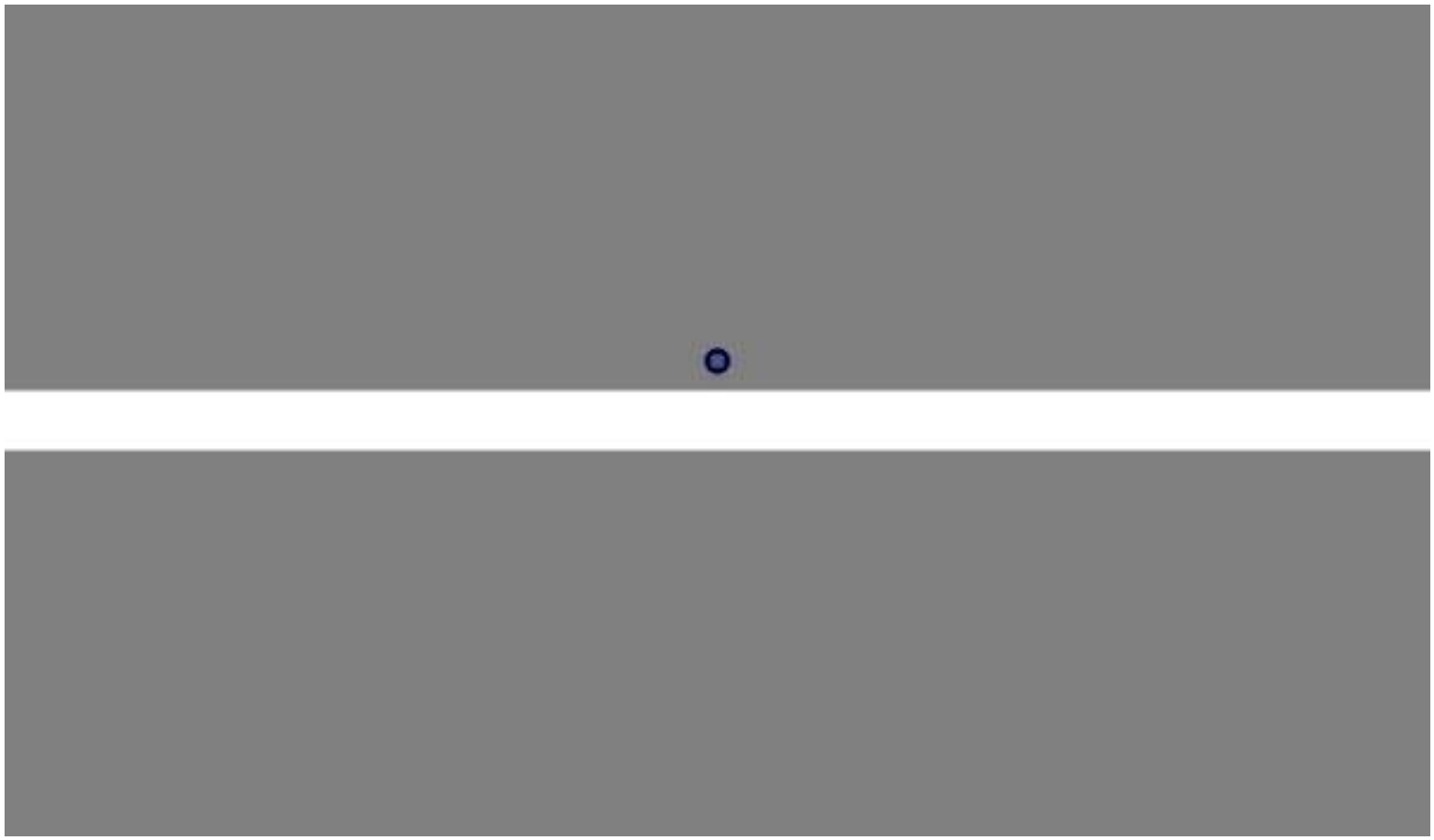
- To account for dispersive properties, must use Drude model of Electric Conduction.
  - Electrons are no longer massless, free particles; instead, assumed harmonically bound to equilibrium position.

- Real part of epsilon defined by infinite frequency limit.
- Term added to account for electron/ion density.
- Term added which assumes electrons harmonically bound to equilibrium position. Ions considered stationary.





Surface Plasmons generated on Ag by narrow bandwidth gaussian source below Plasma frequency.



Frequency of Gaussian source increased to plasma frequency of Ag. Note that no surface plasmons are produced.

Attempted modeling of Kletschmann configuration. Plane wave propagates through high refractive index dielectric and is incident on thin metallic interface.

Applications

- Applications of SPR in imaging include:
  - Detection of thin film absorption on metalic surface
    - Nm film absorption causes angular shift of in resonance angle (absorption wavelength can also be measured).
  - Extension of this technique used to develop Surface Plasmon Resonance Imaging (SPRI).
    - Here, film absorbs multiple material types in varying thicknesses over the surface.
    - Multiple incident beams (wavelengths and angles) are incident on film, and CCD arrays used to measure reflected beam.