SURFACE PLASMA POLARITONS FLOW CONTROL USING EXTERNAL FIELDS

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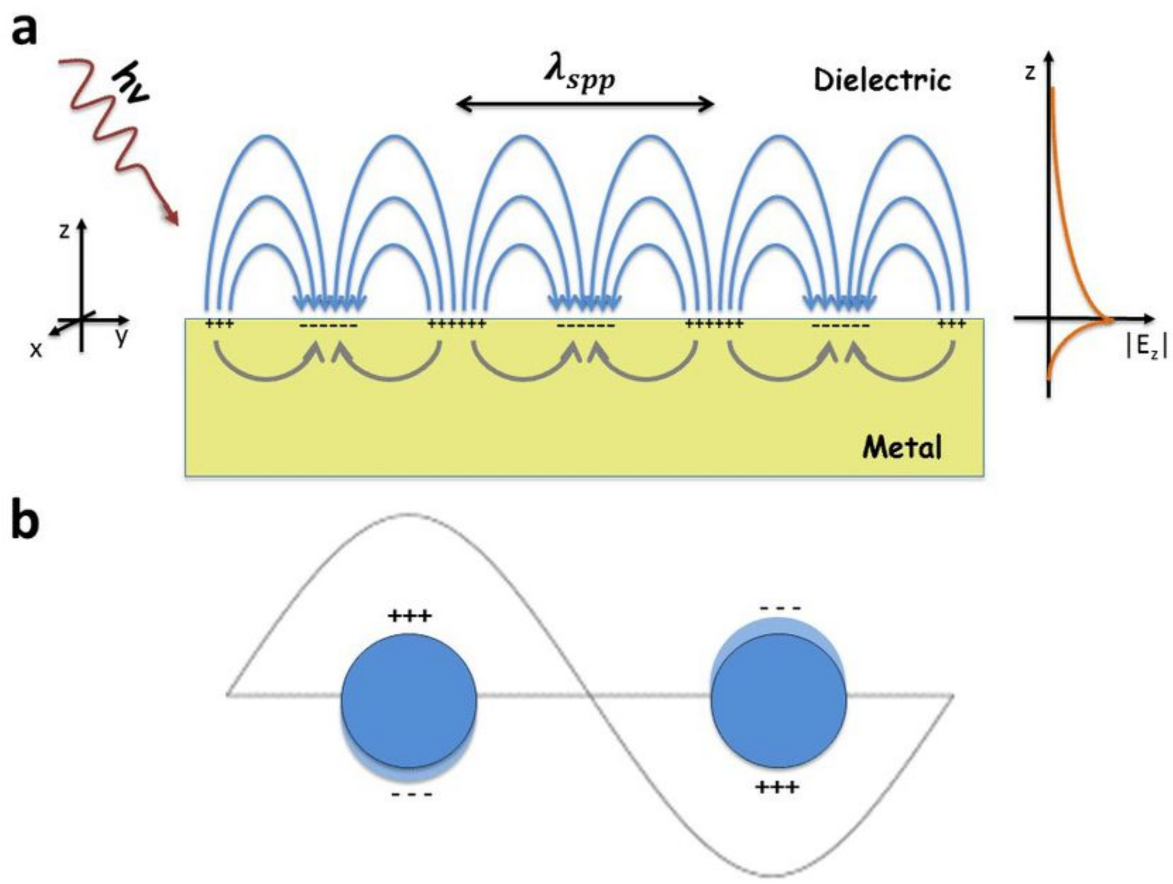
Introduction

Surface plasmon polaritons (SPPs) are generated as a result of the interaction of photons, phonons and plasmons during the propagation of an electromagnetic wave along the interface between a dielectric medium and a metal



Boundary conditions for the SPP for TM-mode

$$H_{y2} = H_{y1} \qquad E_{z2} = E_{z1} \qquad \Rightarrow -\frac{\alpha_2}{\varepsilon_2} = \frac{\alpha_1}{\varepsilon_1}$$

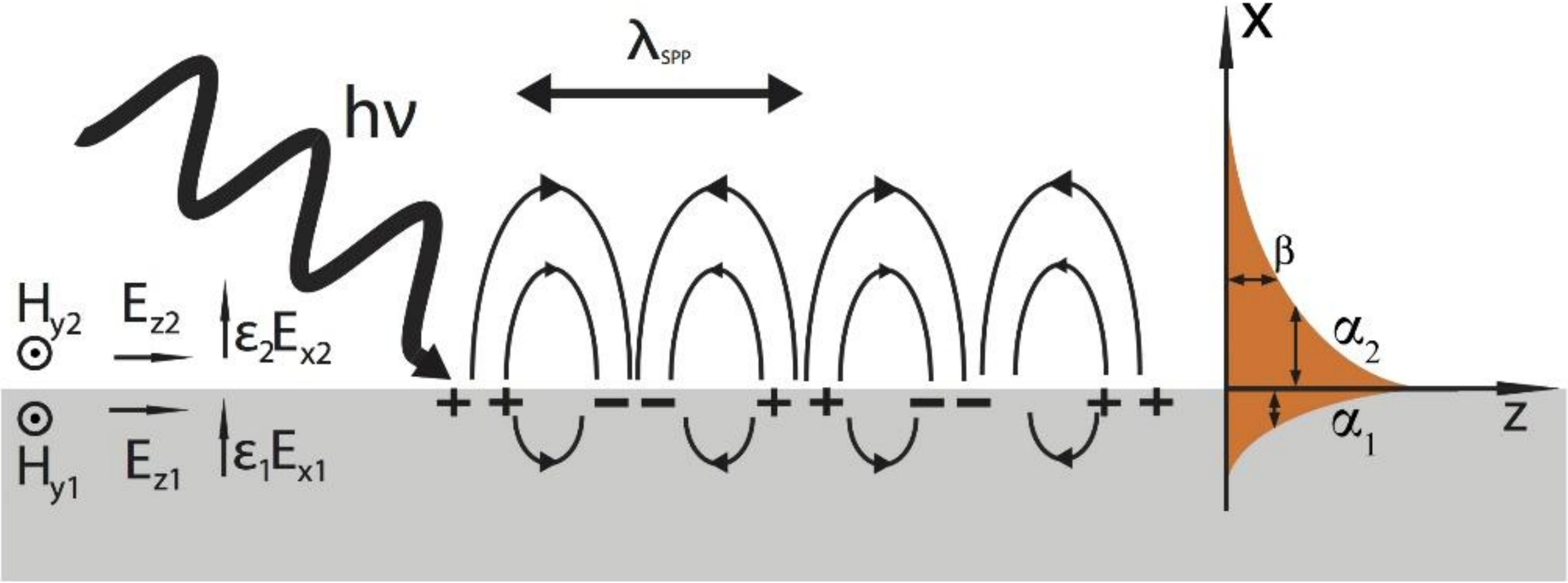
SPP wavelength and propagation constant:

$$\lambda_{SPP} = \frac{2\pi c}{\omega\sqrt{\varepsilon_{eff}}} \qquad \beta = \frac{\omega}{c}\sqrt{\varepsilon_{eff}} \qquad \varepsilon_{eff} = \frac{\varepsilon_2\varepsilon_1}{\varepsilon_1 + \varepsilon_2}$$

β – SPP wave vector

α_1 – attenuation coefficient in medium 1

α_2 – attenuation coefficient in medium 2



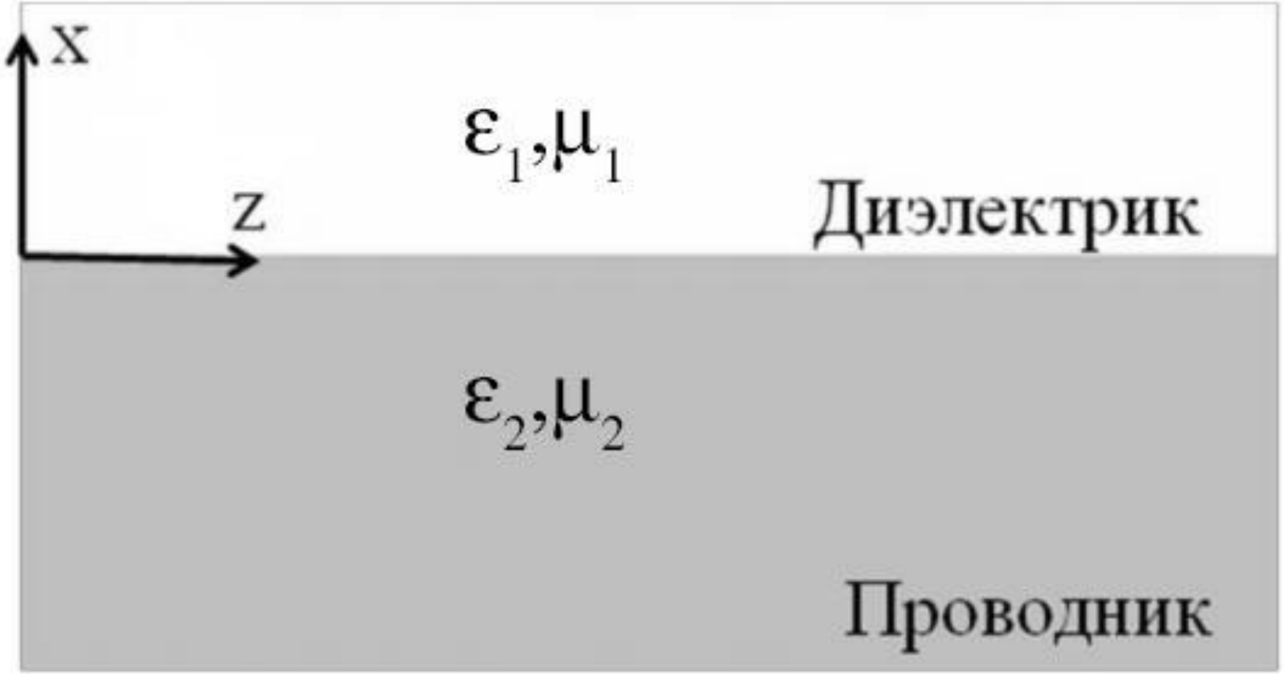
SPP excitation conditions

$\varepsilon_1(\omega) = \varepsilon'_1 + i\varepsilon''_1$ - dielectric constant of metal

ε_2 - dielectric permittivity

1) The real part of $\varepsilon_1(\omega)$ must be negative $\Rightarrow \varepsilon'_1 < 0$
2) ε'_1 modulo should be greater than ε_2 $\Rightarrow |\varepsilon'_1| > \varepsilon_2$

$$\beta = \frac{\omega}{c}\sqrt{\frac{\varepsilon_2\varepsilon_1}{\varepsilon_1 + \varepsilon_2}}$$



$\mu_1 = \mu_2 = 1$

Energy density flux distribution in a metal-insulator system

The plasmon wave decays exponentially in the metal and in the dielectric along the normal axis to the interface

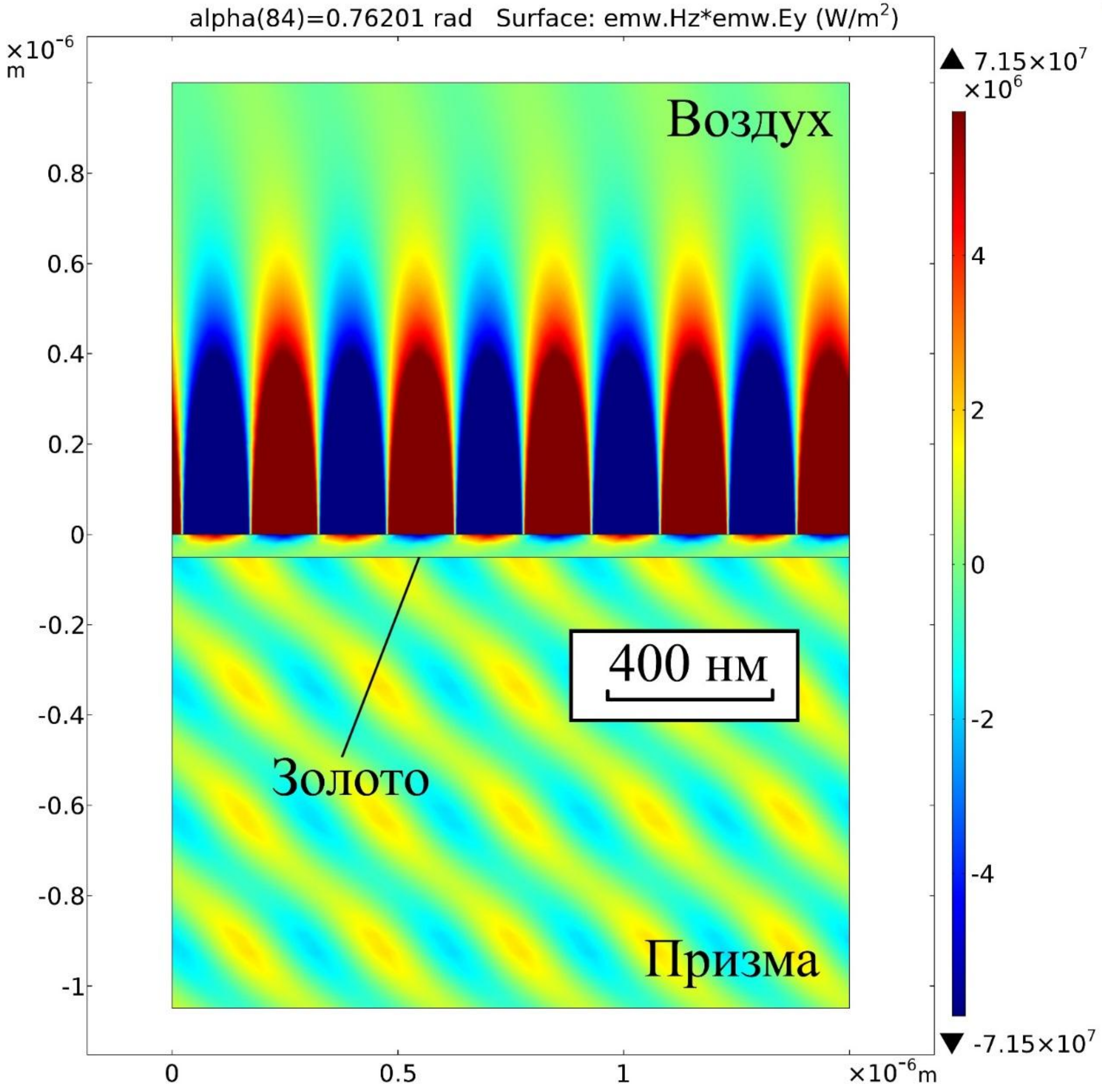
$$\lambda_0 = 633nm$$

$$\varepsilon_{air} = 1$$

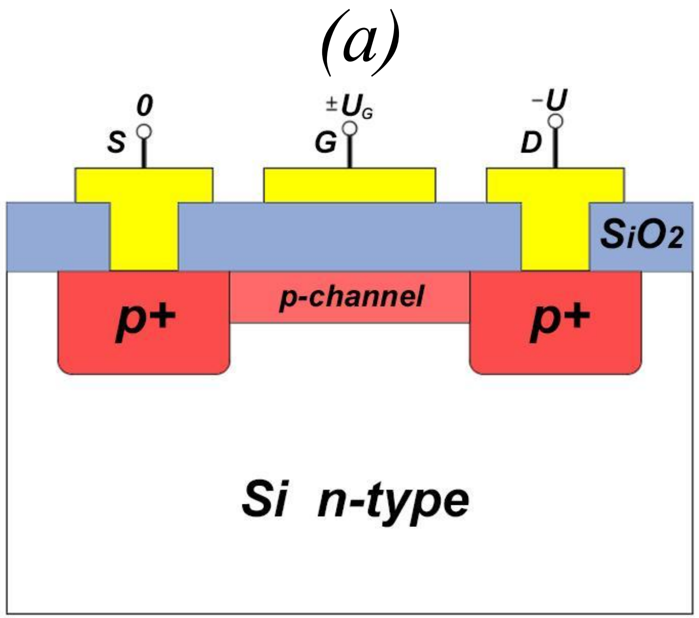
$$Re(\varepsilon_{Au}) = -11.6$$

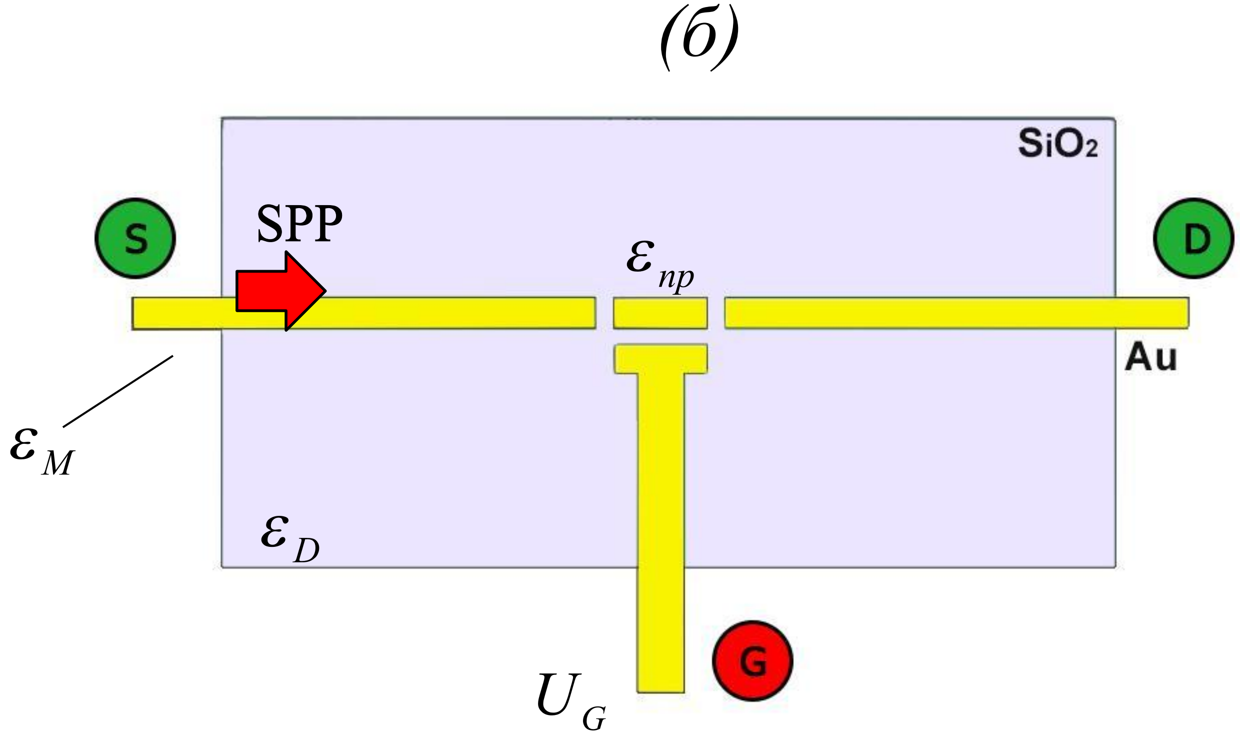
The propagation constant of the SPP on the surface of the strip waveguide

$$\beta = k_0 \left(\varepsilon_{Air} \frac{\varepsilon_{Au} - \varepsilon_{Air}}{\varepsilon_{Au} + \varepsilon_{Air}} \right)^{1/2}$$



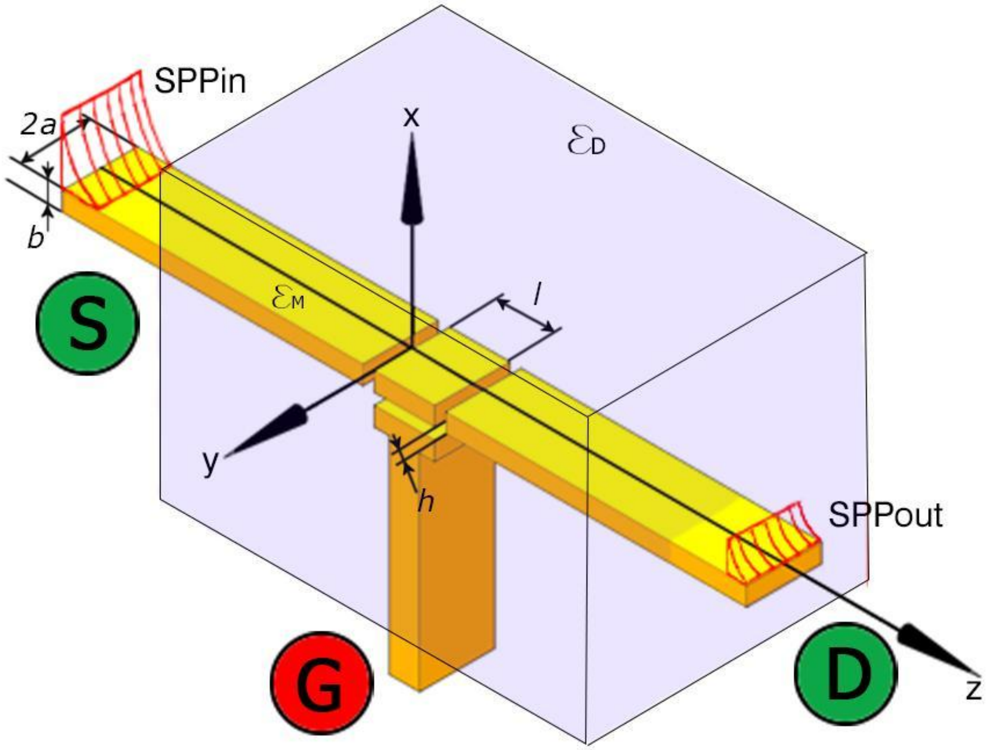
Plasmofield effect transistor operating on the principle of a semiconductor n field effect transistor with an integrated channel





Field effect transistor with integrated channel (a);
Metal strip waveguide (sectional view) (b).
The role of current in a plasmon field effect transistor (PPT) is performed by the SPP flow. ε_{np} – dielectric permittivity of nano-plate.

Model of a plasmon field effect transistor



A metal strip waveguide of length L, width 2a, thickness b, embedded in the dielectric. The nano-plate has a width of l. Shutter G with a flat end is located at a distance h below the lower surface of the nano-plate, from which it is isolated by a thin layer of dielectric

Conclusions

- SPPs at the metal-insulator interface can exist only in the frequency region in which the dielectric constant of one of the media is negative.
- A plasmon wave is highly localized near the interface. The spatial localization of the SPP is the basis for applications in nanoscale structures.
- The dielectric constant of a metal-dielectric nanostructure can be locally changed by changing the amplitude of the SPP signal supplied to the control electrode of the PPT. In this case, it is possible to modulate the energy flux density of the SPP propagating over the surface of a plasmon strip waveguide.
- A method for controlling SPP signals using external fields is very effective for use in nanoplasmon devices.

Thanks for your attention