Surface plasmon oscillations control by nematic liquid crystal reorientation

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INTRODUCTION

We present the study of the surface plasmon polariton propagation properties control by imposing a reorientation in the adjacently located nematic liquid crystal. A plane nematic liquid crystal cell, initially oriented homeothropically, is placed into a static electric field parallel to the substrates (Fig. 1). Due to the influence of the electric field the liquid crystal starts to deviate from the initial orientation, posing a change in the dielectric function of the liquid crystal cell. One of the substrates of the liquid crystal cell contacts with a thin metal coating, on the interface with which the surface plasmon polariton can propagate. The properties of the surface plasmon polariton (most importantly the effective refractive index) are reflecting the change of the liquid crystal orientation.

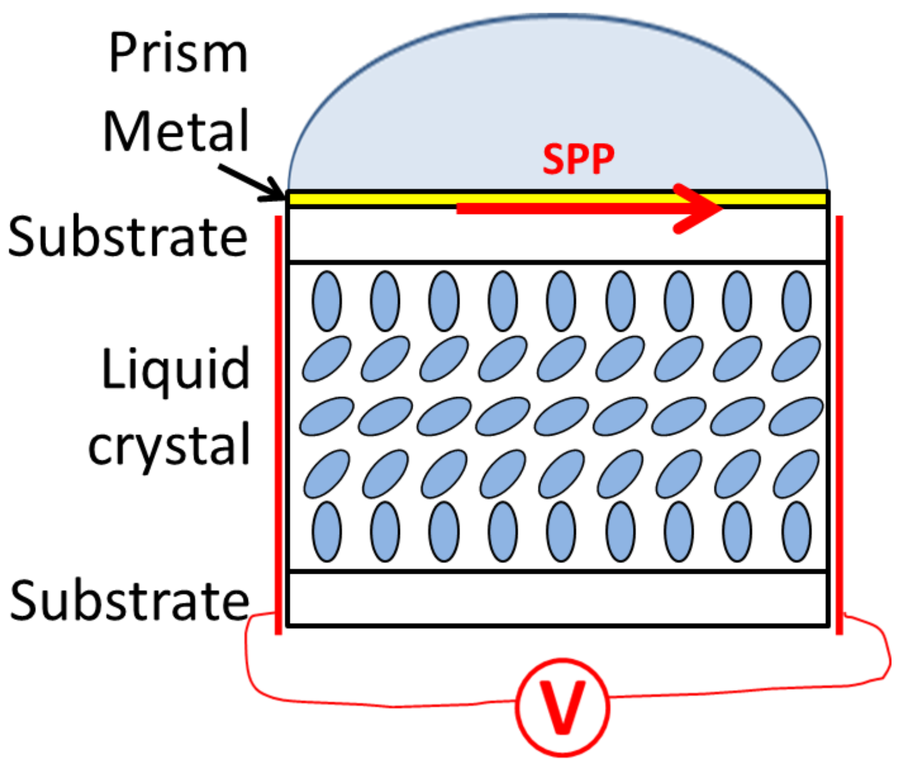

Fig. 1. Plasmonic liquid crystal cell with a hemispherical prism to allow SPP coupling.

METHODS

The calculation of the surface plasmon polariton properties in such structure was performed both analytically, using an adapted perturbation technique presented in [1], as well as by direct numeric solution of the Maxwell's equations. The dielectric function of the investigated structure is determined by the principal values of the dielectric permittivities as well as by the director profile of the liquid crystal. The latter is calculated by analytically minimizing the free energy of the liquid crystal cell, as described in [2].

RESULTS

The dependence of the effective refractive index n_{eff} on the value of the applied voltage is shown in the Fig. 2. For a significant range of voltages near the director reorientation threshold the effective index has up to 3 different stable states (denoted by solid lines), indicating the presence of up to 2 hysteresis.

The transitions between the stable states (marked with the arrows) form the boundaries of the hysteresis. The position of the lower hysteresis is sensitive to the value of the anchoring energy: marginal increase of the anchoring energy significantly shifts the lower hysteresis towards larger voltages, while the position of the upper hysteresis practically remains the same.

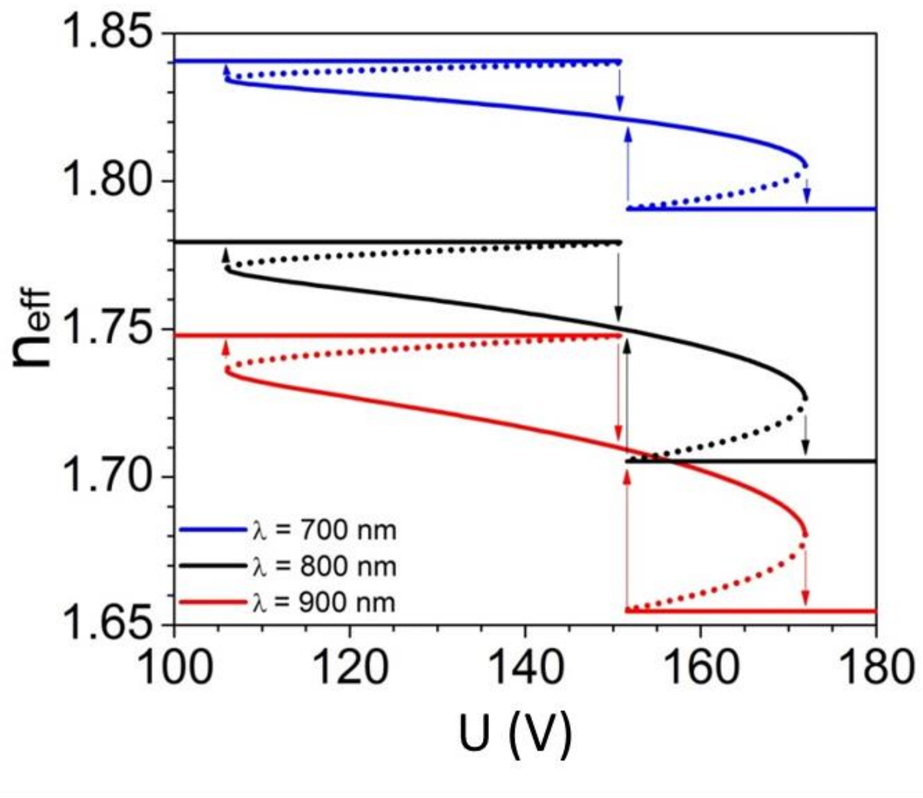

Fig. 2. Dependence of the effective refractive index on the applied voltage possesses a hysteresis.

For different vacuum wavelengths of the incident light the voltages of the transitions in the hysteresis do not change, while for larger wavelength the amplitudes of the hysteresis transitions increase and the values of the effective index decrease.

CONCLUSION

The effective refraction index of the surface plasmon polariton as a function of the external electric field strength can possess a hysteresis-like behavior. That is, the effective refractive index is an ambiguous function of the electric field strength, and its value is highly influenced by the preceding state of the system. The parameters and criteria for such hysteresis to occur are calculated. Such phenomenon is likely to prove useful in constructing plasmonic switches and basic memory units.

REFERENCES

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