Liquid crystal control of the electromagnetic wave propagation through metal-multilayer dielectric structure

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Abstract: We consider metal-multilayer dielectric structure consisting of a glass layer, thin silver or aurum layer, liquid crystal and alternating high (TiO_2) and low (SiO_2) refraction index quarter-wave layers (Bragg reflector, DBR). There is a defect layer between the metal layer and the liquid crystal (LC). The tilt angle of the liquid crystal is changed by applying an electrical voltage to the LC layer. Changing the angle of the LC director allows to control the optical properties of the device, which can be used, for example, in optical sensors.

To study the optical properties of the device under consideration (**Fig**.1), we chose the basic values of the structure parameters: $dTiO_2$=0.063μm, $dSiO_2$=0.11 μm, dLC=0.6mμ (LC-mixture 1825) [1,2], n_{glass}=1.5, noLC= 1.55, neLC = 1.94. Figures 2-4 show the results of our numerical simulation of the metal-dielectric structure with optimized parameters N = 7 and dLC = 0.6μm ; defect layer thickness dDef = 10 nm, and LC director angles 0 – 90°. A defect layer of metal-dielectric structure comprise of a thin layer of dielectric (e.g. SiO2 or TiO2). Gr in Fig.1 – thin graphene electrodes [3].

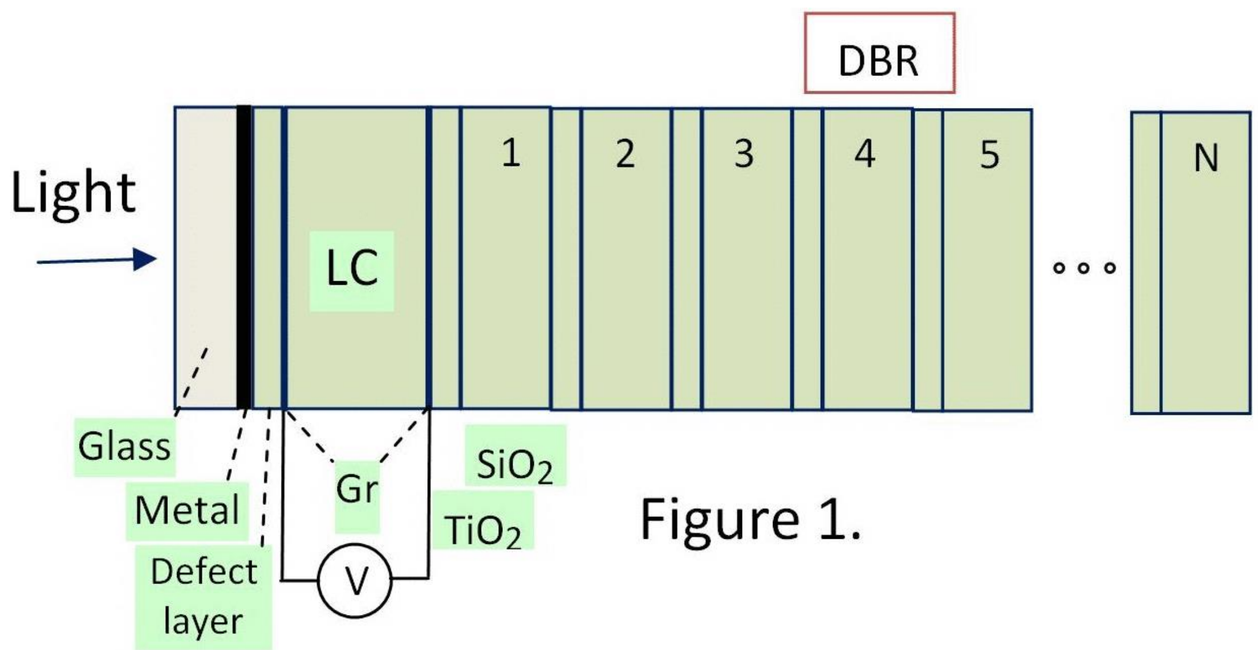

Figure 1.

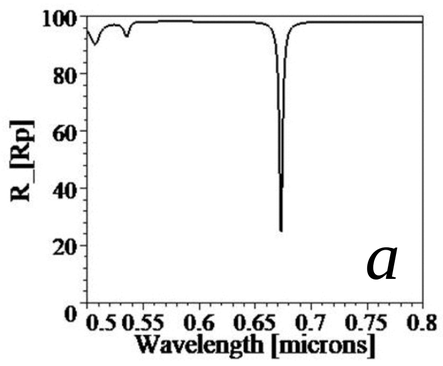

Figure2.

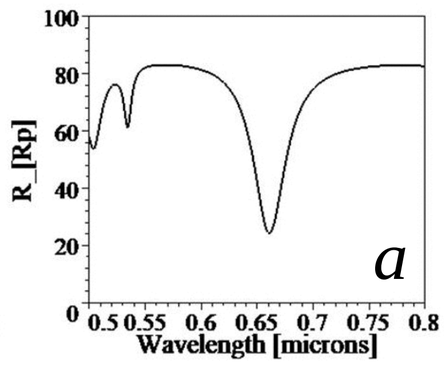

Figure 3.

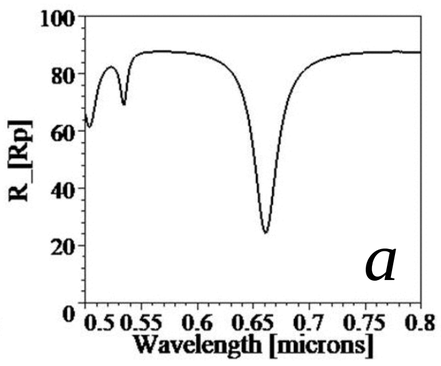

Figure 4.

Fig. 2 shows the shift of resonant dip to the left when the LC director angle is changed by 90°.

Fig. 3 shows the effect of reducing the thickness of the defect layer to 1 nm (metal Au).

Fig. 4 shows the effect of reducing the thickness of the defect layer to 1 nm (metal Ag).

In Figures 2-4 LC director angle 0° (a) and 90° (b).

References

[1] High birefringence liquid crystal mixtures for electro-optical devices, E. Nowinowski-Kruszelnicki et al, Optica Applicata, Vol. 42, No. 1 (2012).

[2] Highly birefringent, low-loss liquid crystals for terahertz applications, M. Reuter et al, Appl Materials, Vol.1, 012107 (2013).

[3] Graphene electrodes for lithium-niobate electro-optic devices, Z. Chang, W. Jin, and K. S. Chiang, Optics Letters, Vol. 43, No.8 (2018).