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Institut d'Electronique, de Microélectronique et de Nanotechnologie
UMR CNRS 8520

Master and Engineer Internship: 2018-2019

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Title : Temperature tunable one-way magnetoplasmonic mirrors at mid-infrared frequencies on InSb and InAs

Abstract : We have recently demonstrated that by exploiting cyclotron resonances of the highly mobile and light carriers in small gap semiconductors such as InAs and InSb, occurring when these are subjected to moderate magnetic fields, one can induce interesting nonreciprocal reflection behaviours at wavelengths in the TeraHertz part of the spectrum. By etching a properly designed diffraction grating in such semiconductors, the resulting structure mirror will effectively behave as an almost perfect one-way mirror under well controlled directions of the applied magnetic field and specific incidence angles. Whereas it will perfectly reflect incoming light, for the opposite sense strong coupling to the plasmonic cyclotronic resonance will almost perfectly absorb incoming light.

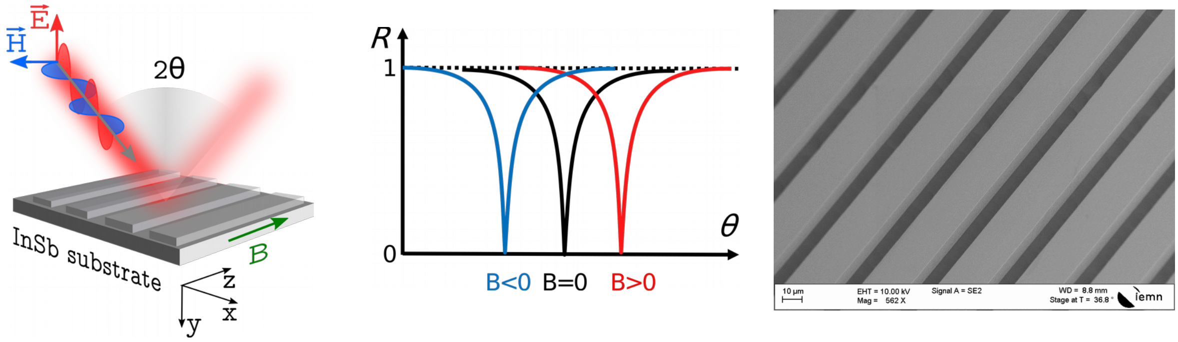

Fig1 (a): schematic representation of the NR InSb magnetoplasmonic mirror and its working principle. (b): SEM picture of a fabricated wet etched grating in InSb (period 68µm and slit depth 5µm)

The experimental demonstration of this effect at THz frequencies this year by our group was a world premier [1] and solved a very important problem in THz research, namely the absence of a competitive isolating device with sufficiently low losses. Not only is this the first demonstration of isolation at THz frequencies, what is interesting about this approach is its tunability. As the operational principle is based on high frequency dynamics of a free carrier plasma, controlling its density allows to tune the spectral properties of the nonreciprocal reflection. A direct way to achieve this is by temperature control of the semiconductor. The goal of this internship is to assist with the ongoing research towards extending this concept to mid-infrared (MIR) wavelengths (with λ anywhere between 5 and 20 μm). Such a device could have an important impact on the use of MIR QCL lasers by hugely improving their spectral and power stability. Their use as pump lasers for instance would hugely improve.

The intern will contribute both to the design and the characterization of these novel devices. He/she will gain experience in the modelling of advanced magnetoplasmonic structures using both commercial and in-house developed software. At the same time an important part of the internship will be devoted to modifying the existing magneto-optic reflection setups to include temperature control. The demonstration of thermally tunable magnetoplasmonic mirrors using these setups will be a final goal. If successful these demonstrations might lead to a number of scientific journal publications. The potential candidate will show sufficient background in photonics and semiconductor physics. Experience with numerical modelling is a plus.

[1] Stepanenko et al, "Experimental Demonstration of 16dB Isolation at Room Temperature on a Magnetoplasmonic One-Way Mirror Exploiting THz Cyclotron Resonances in Narrow Gap Semiconductors", paper STu4D.7, CLEO San Jose 2018.