Room temperature, high speed, mid-infrared Stark-shift modulator on InP

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Highly sensitive and ultrafast mid-infrared optoelectronic systems[1] are required for free-space communications[2], light detection and ranging (LIDAR), high resolution spectroscopy and in observational astronomy.

In this work we present a high-speed room temperature InP-based external modulator at 9 µm. The device is based on a system of *n*-doped asymmetric coupled GaInAs/AlInAs quantum wells grown by MOCVD on an InP substrate. When applying a bias on the device, the transition energy between states 1 and 2 is submitted to a linear Stark shift. The absorption can thus be put in and out of resonance with respect to a fixed laser frequency[3,4] (see left panel of Fig. 1). The absorption can be tuned over more than 40 meV with fields < 70kV/cm, allowing to switch between a transparent and an absorptive configuration (see right panel of Fig. 1) with a highly linear behaviour. Note that the modulation is not performed by depleting electron concentrations. The device is therefore characterized by an intrinsically large bandwidth and very low electrical power consumption (~ few mW) with respect to direct laser modulation. In order to take advantage of this intrinsically ultrafast modulator, special care was taken to process this quantum structure into a RF-compatible device able to operate up to several GHz[5]. We report here 47% modulation depth for our modulator, which shows bandwidths of up to tens of GHz. The limit in modulation speed appears to be eventually limited by the packaging of the device and not by the underlying physics, showing the great potential of this concept for high bitrate data transmission.

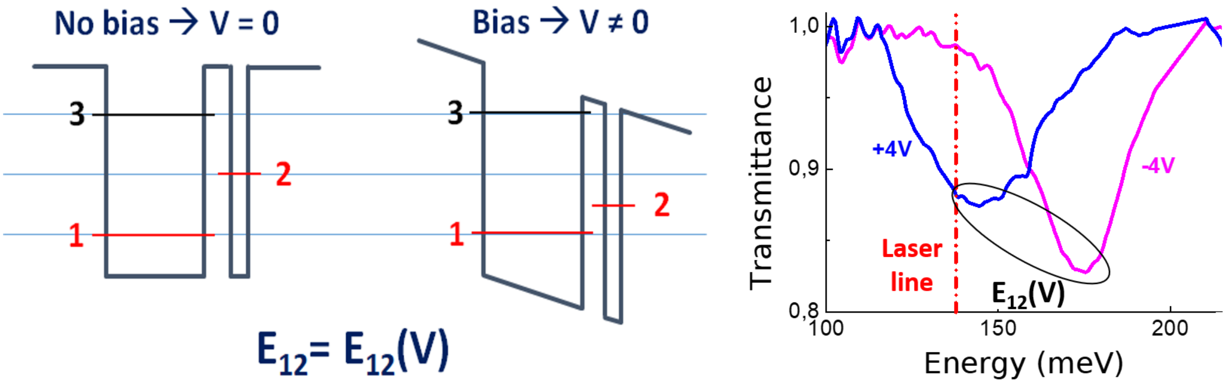

Fig. 1: Left: Conduction band diagram illustrating the Stark-shift of E_{12} transition, tunable with an external electric field. Right: Transmission spectra under bias. At positive bias (blue) the laser light is absorbed while under negative bias (pink) the modulator becomes transparent.

References:

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