

Development of high-speed, patch-antenna intersubband photodetectors at 10.3 μm

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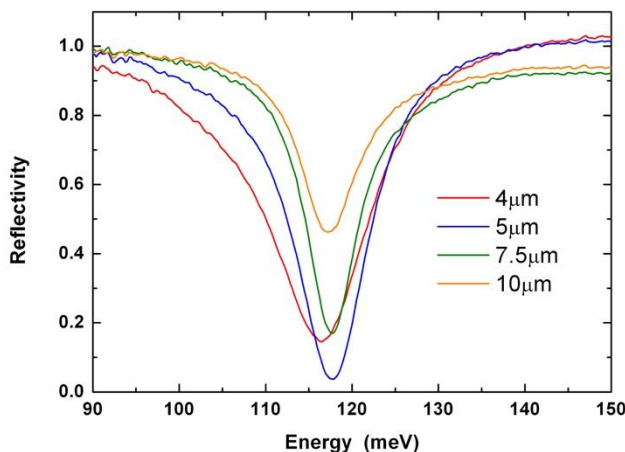
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Abstract: We present our work towards the development of high-speed, GaAs-AlGaAs multi-quantum wells photodetectors at 10.3 μm , based on two-dimensional arrays of patch-antenna resonators. First, the results of FDTD simulations will be presented that allowed to optimize the patch array geometry and fabricate a first generation of detectors with microwave coplanar access. Next, we will report on our initial results from *dc* optical characterization, namely reflectivity and photocurrent measurements.

INTRODUCTION

Mid-infrared intersubband (ISB) photodetectors based on two-dimensional arrays of patch resonators (PRs) have recently shown promising results in terms of high sensitivity at room temperature, as well as high speed, with heterodyne detection up to 4GHz demonstrated at 8.2 μm [1]. These results stem from the exploitation of the antenna effect, allowing a reduction of the detector physical area without compromising the photon collection [2]. Compared to standard photodetectors geometries, this brings a reduction of the dark current, and allows minimizing the device RC time constant, hence widening the RF bandwidth. Exploiting this novel detector's concept at even longer wavelengths appears particularly appealing, since it can allow achieving background



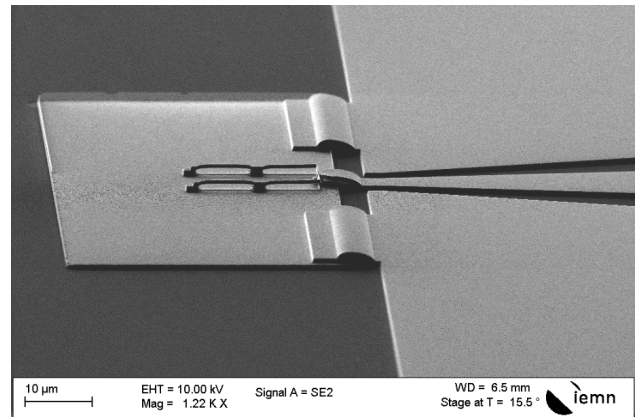
limited operation above liquid nitrogen temperatures.

Fig. 1. Reflectivity measurements on 2D arrays (300x300 μm^2) of square PRs with different periods (4 μm , 5 μm , 7.5 μm , 10 μm). The PRs side is 1.9 μm .

Here we report on our work on the development of PR photodetectors optimized for operation at 10.3 μm . These

are based on a GaAs-Al_{0.2}Ga_{0.8}As MQW heterostructure consisting of seven 6.5nm GaAs wells, separated by 40nm barriers. First, we will present the results of a study based on FDTD simulations aimed at establishing the array periodicity that allows reaching the critical coupling condition at the desired wavelength [2]. These results are compared to reflectivity measurements performed on large 2D arrays of PRs (300x300 μm^2) and obtained with a mid-IR microscope coupled to a FTIR spectrometer (Fig.1).

Next, the results of *dc* photocurrent measurements will be presented. These include photocurrent spectra performed on mesa devices, to assess the position of the ISB transition, and *dc* photocurrent vs voltage characteristics



obtained with a 10.3 μm quantum cascade laser (QCL). The latter

Fig. 2. SEM picture of a fabricated 10.3 μm ISB photodetector based on 2x2 2D-array of square PRs of 1.8 μm side.

were recorded on a set of devices consisting a small 2D arrays of PRs (2x2, 3x3 and 5x5) provided with a 50 Ω coplanar access for high speed operation (see Fig.2). These devices were fabricated using e-beam lithography and ICP-RIE plasma etching and include suspended metallic bridges to electrically connect the PRs without affecting the dark current. Heterodyne measurements using two DFB QCLs are presently under way and the results will be presented at the conference.

REFERENCES

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