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Position sensitive photon detectors using epitaxial InGaAs/InAlAs quantum-well

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This work deals with investigation of novel position sensitive devices based on InGaAs/InAlAs Quantum Well (QW) for several applications of either synchrotron or conventional light sources. Such QW devices may be used as fast and efficient detectors due to the direct, low-energy band gap and high electron mobility at Room Temperature (RT).

Metamorphic In_{0.75}Ga_{0.25}As/ In_{0.75}Al_{0.25}As QWs containing a two-dimensional electron gas (2DEG) were grown by Molecular Beam Epitaxy (MBE). The carrier mobility at RT was 1.2×10⁴ cm² V⁻¹ s⁻¹.

Two devices with size of 5×5-mm² were prepared by using optical lithography. In the first, the active layers were segmented into four electrically insulated quadrants. Indium Ohmic contacts were realized on the corner of each quadrant (for readout) and on the back surface (for bias).

In the second, the QW was left unsegmented and covered by 400 nm of Al providing a single bias electrode, while four readout electrodes were fabricated on the back side by depositing and segmenting a Ni/Ge/Au layer. This configuration should be beneficial for the fabrication of pixelated detectors.

Photo-generated carriers can be collected at the readout electrodes by biasing form either the QW side or the back side of the devices during beam exposure. Individual currents obtained from each electrode allow to monitor both the position and the intensity of the impinging beam for photon energies ranging from visible to hard X-ray.

Such detector prototypes were tested with Synchrotron Radiation (SR), conventional X-rays and 400-nm laser light. The results obtained with X-ray SR show how these devices exhibit high charge collection efficiencies, which can be imputed to the charge-multiplication effect of the 2DEG inside the QW. Moreover, the position of the beam can be estimated with a precision of 800 nm in the segmented QW. A lower precision of 10 µm was recorded in the unsegmented QW due to the charge diffusion through the 500-µm-thick wafer. When tested with a 400-nm, 100-fs table-top laser, these devices responded with 100-ps rise-times to such ultra-fast laser pulses.

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