8×8 photodiode array based on P-*InAsSbP*/n-*InAs* single heterostructure

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There have been considerable progress over the last decade in developing *InAs* homojunction photodiodes (PDs) including the p-i-n PD arrays for fast response sensing of IR radiation around 3 μm [1]. InAs based heterojunction photodiodes, e.g. *InAsSbP/InAs* based ones, potentially offer high R_oA product values but most of related investigations were devoted to PDs with abrupt impurity distribution near a p-n junction that is not optimal for high speed operation. To the best of our knowledge there has been only one paper describing operation of InAs heterostructure array near room temperature [2], however room temperature detectivity value was not high enough for some of the sensing applications.

The report presents characterization of P-*InAsSbP*/n-*InAs*/n+-*InAs*(100) single heterostructure PD array of 8×8 dimensions in the 77-385 K temperature range.

Wafers onto heavily doped n^+-*InAs* (*Sn*) (100) substrates with an electron concentration of n^+= (2-3)·10^{18} cm^{-3} contained two epitaxial layers: 3-4 μm thick n-*InAs* active region and P-*InAsSbP* (*Zn*) (E_g ≈ 0.48 eV, 77 K, P=(2-5)·10^{17} cm^{-3}) cap layer. Monolithic 8×8 matrix contained 64 individually addressable PD elements of ~190×190 μm size.

Capacitance measurements revealed no impact of the frequency on zero bias capacitance in the 0-2 MHz range and showed reverse cubic dependence on bias suggesting nearly linear impurity distribution near a p-n junction. I-V_{FB} curve ideality factor exhibited minima around 200 K (β =1.03) and reached β =1.2 value at low and elevated temperatures showing negligible influence of tunneling. The latter together with the independence of the (C^{-3})-V slope on temperature states negligible influence or lack of deep recombination centers in P-*InAsSbP*/n-*InAs* single heterostructures under study. As a result nearly unity internal quantum efficiency and nice PD operating parameters have been achieved at low temperatures including low capacitance (10^{-7} F·cm^{-2}, 77 K) and high detectivity values in the thermoelectric range of temperatures and BLIP operation at ~200 K.

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References

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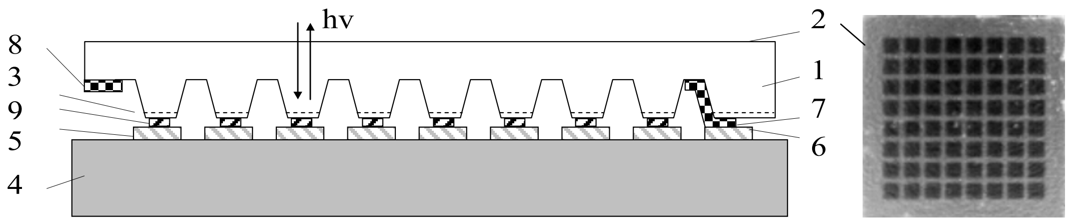

Fig.1. Schematic (left) and IR image (I_{RB}=-2 mA, right) of the BSI array. 1- P-*InAsSbP*/n-*InAs*/n^+-*InAs* single heterostructure, 2 –n^+- *InAs* surface, 3 – mesa walls/p-n junction, 4 – *Si* read-out plate, 5 – anode bonding pads, 6 – cathode bonding pad , 7 – contact to n^+-*InAs*, 8 –ring contact to n^+-*InAs*, 9 – contacts to individual anodes. Items 7 and 8 have short circuit.

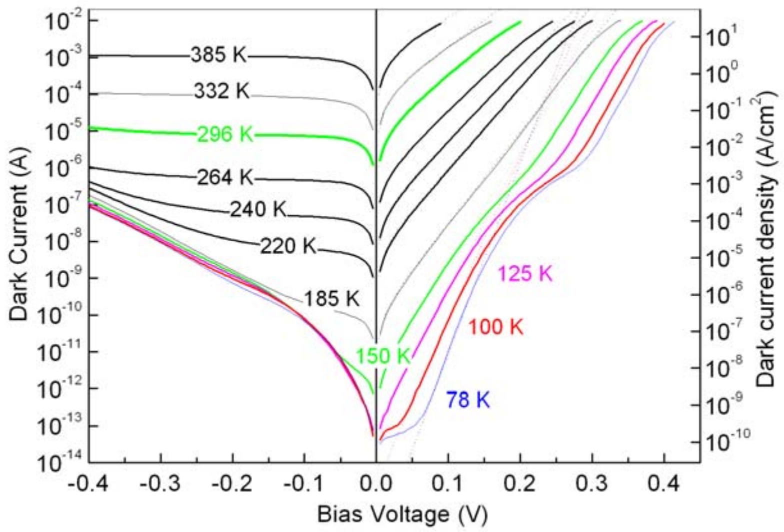

Fig.2. I-V characteristics of the single array element in the 73-385 K temperature range..

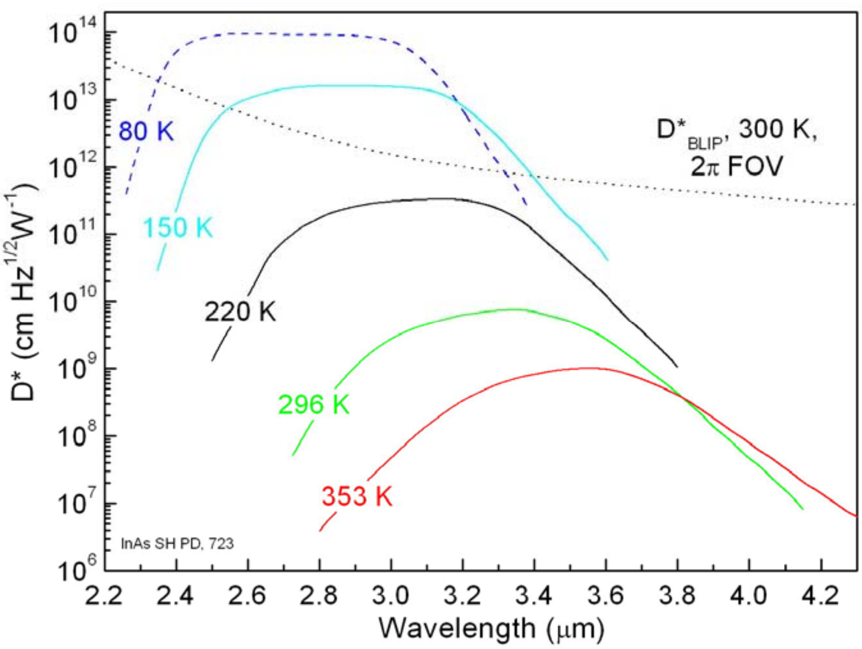

Fig.3. Detectivity spectra of a single array element at 80, 150, 220, 296 and 353 K.