Silicon Nanostructure Detector With Sub-Bandgap Infrared Response

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BACKGROUND

Silicon nanostructures have attracted enormous attention in the past two decades due to their unique optical properties that cannot be observed in their bulk counterparts. However, since intrinsic silicon has negligible response to infrared photons (λ>1.15 μm) with energies lower than its bandgap energy, it poses a great challenge to use silicon as an active absorbing material for infrared photodetection. In order to realize all-silicon CMOS compatible infrared photodetectors, various approaches have been investigated including incorporation of germanium with silicon as the optically responsive element, two photon absorption process, and surface-plasmon Schottky detectors. The success of these earlier approaches has been limited.

TECHNOLOGY DESCRIPTION

University researchers have developed fabrication methods and devices that enable greatly enhanced photoresponse to sub-bandgap energy photons in indirect bandgap semiconductors. Proof of concept has been achieved with a vertically arrayed silicon nanowire-based device that exhibits voltage dependence of photoresponse to infrared sub-bandgap optical radiation. The device is fabricated using a proximity solid-state phosphorous diffusion method to convert the surface areas of highly boron-doped silicon nanowires into n-type, thus forming a radial core-shell p-n junction structure. The attractive characteristics are based on three physical mechanisms: the Franz-Keldysh effect, quasi-quantum confinement effect, and the impurity-state assisted photon absorption. The concept and approach can be applied to materials other than silicon to significantly extend the operable wavelength regime beyond the constraint of energy bandgap. The invention could enable highly efficient, low cost, and CMOS compatible infrared photodetectors and focal plane arrays using single crystal silicon nanostructures.

RELATED MATERIALS

- Bias Dependence of Sub-Bandgap Light Detection for Core–Shell Silicon Nanowires NanoLetter 2012, 12 (11), pp 5929–5935 - 10/25/2012

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	9,728,662	08/08/2017	2013-053

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OTHER INFORMATION

KEYWORDS

Silicon nanowire, sub-bandgap absorption, nanophotonics, photodetection

CATEGORIZED AS

- **Optics and Photonics**
  - All Optics and Photonics
- **Nanotechnology**
  - Other
- **Semiconductors**
  - Materials

RELATED CASES

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