

INTERNATIONAL MEETING ON

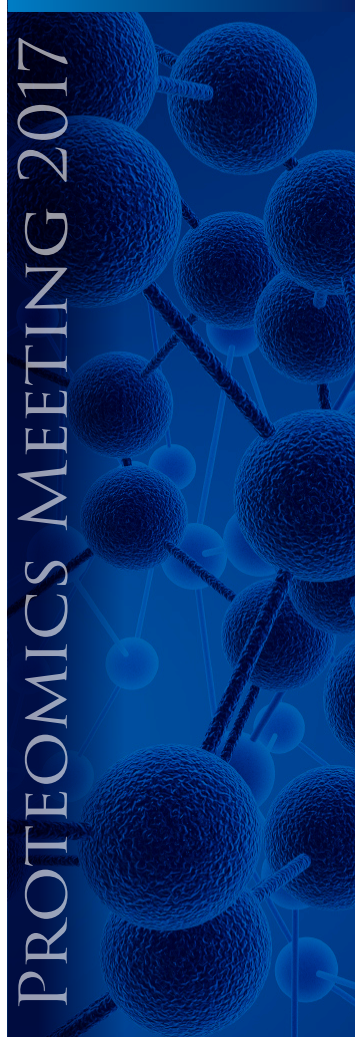
ADVANCED NANOMATERIALS AND NANOTECHNOLOGY

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Ultrahigh responsivity near infrared photo detectors based on single semiconductor nanowires

In this report, we show that ultra-high responsivity ($R > 10^5$ - 10^6 A/Watts) Near Infra-Red (NIR) photodetectors can be made from single strand of nanowires of semiconductors like Si, Ge or molecular materials like Cu:TCNQ. The nanowires used were all grown by vapor phase methods and the single nanowire devices were fabricated on SiO₂/Si substrate where the electrical leads were made using a combination of optical lithography and nanolithography tools such as electron beam lithography and lift off or focused ion beam or focused electron beam deposition methods. The typical device lengths are in the range of 1-5 microns and then nanowire strands have a diameter < 100 nm. The distance between the electrodes was brought down to below 300 nm. In case of the molecular material Cu: TCNQ, which gives a narrowband detector, a peak responsivity of 10^4 - 10^5 A/W can be reached at 405nm with nanowire of diameter 30nm. In case of Si nanowires (diameter ~ 80 -100nm), the response is broad band and a responsivity $> 10^4$ A/W can be reached over the wavelength of 500nm to 1150 nm. For Ge nanowires, the response can be seen even over broader wavelength region extending well into the NIR region limited by the band-width of Ge (1850 nm). The peak responsivity in this case can reach even 10^6 A/W at wavelength range 800 nm-1000 nm. Though not very large reasonable responsivity, can also be seen from single strands of Y-junction CNT. The ultra-high sensitivity in single nanowire devices are contributed by a number of factors that include: (1) very close distance between electrodes, (2) small diameter allowing for photo-transistor effects at the surface of nanowires and (3) diffusion of photo generated carriers lowering the Schottky barrier at the contact interface.

Recent Publications

1. K Das, S Mukherjee, S Manna, S K Ray and A K Raychaudhuri (2014) Single Si nanowire (diameter ≤ 100 nm) based polarization sensitive near-infrared photodetector with ultra-high responsivity. RSC Nanoscale; 6: 1123.
2. Sudeshna Samanta, Deepika Saini, Achintya Singha, Kaustuv Das, P R Bandaru, A M Rao, and A K Raychaudhuri (2016) Photoresponse of a Single Y-Junction Carbon Nanotube. ACS Applied Materials and Interfaces; 8: 19024.

Biography

A K Raychaudhuri has obtained his MSc from IIT Kanpur and PhD from Cornell University, Ithaca, USA. He had Post-doctoral experience at the Max Planck Institute, Stuttgart as an Alexander von Humboldt Fellow. He has worked as a Professor at Indian Institute Science Bangalore, the Director of National Physical Laboratory, New Delhi and as the Director of S. N. Bose National Centre for Basic Sciences, Kolkata, where he is currently a Distinguished Professor Emeritus and J C Bose Fellow. His research interests cover condensed matter physics and materials physics. His current research mainly focuses on nanomaterials that include nanofabrications using nanolithography techniques such as use of electron-beam and ion-beam lithography for fabrication of single nanowires based devices including ultra-high responsivity single nanowire photodetectors. He is a Fellow of all the Science Academies in India and is a winner of the S S Bhatnagar Award in Physical Sciences in 1994.

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