European Journal of
Applied Engineering and Scientific Research

Abstract

Novel Hybrid 2D-3D heterostructures for photodetection applications

Nisha Prakash
Academy of Scientific and Innovative Research (AcSIR), India

Abstract:
Melding of two-dimensional (2D) materials with conventional three-dimensional (3D) materials is leading to new, versatile, and robust photodetector devices. We have developed devices utilizing reduced graphene-oxide on gallium nitride material and graphitic carbon-nitride on silicon. The devices demonstrate significant enhancement in the performance in terms of their figure-of-merits parameters as compared to the respective parent platforms. The main aim of this talk is to propose a new generation of low-cost, high performance photodetectors with enhanced device performance as compared to current prevalent technologies.

Carbon Nitride in its graphitic form (g-C3N4) is often referred as a next generation material for energy harvesting devices, storage, photo-catalyst and in particular optoelectronic applications. The inherent semiconducting nature, chemical inertness and tunable bandgap have leveraged the g-C3N4 with unique properties for device fabrication when compared to graphene. Our first study is based on monolithic integration of self-doped, highly exfoliated g-C3N4 (2D) with Si (3D), which demonstrates operability in self-powered mode showing high response and recovery speed along with an ultrabroadband spectral response from 250-1650 nm, furthering the inherent response of commercial Si DH photodetector (250-1100 nm). The same device displays for the first time, a broad range binary photoswitching behavior from 250 to 1350 nm. Here, we show for the first time, how g-C3N4 could be utilized to develop a highly efficient Si integrated self-powered photodetector.

Gallium Nitride (GaN; 3D) generally shows persistence photoconductivity behavior and/or large leakage current limiting its applications in extreme environments. However, charge compensated highly resistive GaN (HR-GaN) when integrated with thin (few 10s of nanometer thick) reduced graphene-oxide (r-GO; 2D) as an overlayer can create unique properties for applications in harsh environments, working upto ±200 V bias and 120 C with long-term stability over 18 months. The results of our study are relevant to the audience because we show for the first time a solution-cast rGO (soft 2D material) integrated with high-resistive GaN leading to a long-term stable device that could withstand high-temperature and high-voltage environments, suitable for future smart-sensor application.

Biography:
Nisha Prakash received her Ph.D. degree in Engineering Sciences from Academy of Scientific & Innovative Research, at CSIR-National Physical Laboratory campus, India in 2020. She received her B.Tech. degree in Electronics & Communication Engineering in 2004 and M. Tech degree in VLSI Design in 2008 from Guru Gobind Singh Indraprastha University, India. Her current research interests include the application of two-dimensional (2D) and three-dimensional (3D) materials for realization of energy efficient optoelectronic devices.

Publication of speakers:

- Nisha Prakash et al, “Edge-contact large area hetero-structure fast photodetector utilizing two-dimensional r-GO on three-dimensional GaN material interface”, Sensors and Actuators A: Physical, 111720, Vol-3 (2020)
- Nisha Prakash et al, “Binary Multifunctional Ultrabroadband Self-Powered g-C3N4/Si Heterojunction High-Performance Photodetector”, Advanced Optical Materials, 1800191 (2018).
- Nisha Prakash et al, “Ultrasensitive self-powered large area planar GaN UV-photodetector using reduced graphene oxide electrodes”, Applied Physics Letters 109, 242102 (2016)
- Nisha Prakash et al, “The impact of RF-plasma power in carrier relaxation dynamics of unintentional doped GaN epitaxial layers grown by MBE”, Optical Materials, Vol54, pp. 26-31 (2016)

Materials Processing Webinar, December 17, 2020

Citation: Nisha Prakash, Novel Hybrid 2D-3D heterostructures for photodetection applications, December 17, 2020, Dubai, UAE