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# Semiconductor News

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## From the Editor's Desk

The air pollution is increasing day by day at an alarming rate on global scale. According to WHO (World Health Organization) report, more than 80% of the world urban populations are exposed to air quality that exceeds WHO standard levels. The air pollution comprises of number of pollutants such as Sulphur dioxide ($SO_2$), Nitrogen oxides ($NO_x$), Ozone ($O_3$), particulate matter (small suspended particles of varying sizes), Carbon monoxide (CO) and volatile organic compounds ($VOC_s$).

Presently, Indian capital is facing its worst smog since 1999 with peaking values of PM (particulate matter) 2.5 & PM 10. There are several factors responsible for this situation, which includes crop burning, large-scale construction activity, industrial pollution, large number of vehicles and garbage dump etc. It is estimated that around 35 million tons of crops were set afire by surrounding states causing such an emergency situation.

It is essential that we ban the rice stubble burning immediately with a suitable alternative to farmers. Also the traffic regulation and dust control mechanism on construction sites should be monitored ensuring their compliances.

The side effects of industrial civilization are challenging for our generation. Energy harvesting is the need of the hour but not at the cost of pollution.

It is our responsibility to provide a safe and clean environment to next generations. For this, it is necessary that every industry must have an environmental vision and a green policy with proper waste management system. Semiconductor industry can play a lead role to work towards a 'low carbon society'.

In this issue Gallium Nitride Nanoflowers for UV photodetection is presented. We further invite articles from experts to share their research work to this newsletter.

*Dr. Rupesh Kumar Chaubey*

## Executive Committee of SSI

# Gallium Nitride Nanoflowers for UV photodetection

All living species on the Earth are being affected by ultraviolet (UV) radiations. Sun being the main source, nearly 9% of its energy received at higher layers of the atmosphere is in the form of UV radiations. These are highly ionising radiations which may activate several chemical processes. The UV region occupies the spectral interval of λ = 400–10 nm. However, the ozone layer and other atmospheric gases absorb the UV emission from the Sun, and only light with wavelengths > 280 nm reaches surface of the earth. Throughout the world, researchers find potential needs to detect UV for solar UV monitoring, highly secure space-to-space communications, biological sensors, and military uses such as missile detection. The ideal photodetector (PD) for such applications must possess excellent temperature tolerance with improved sensitivity, high responsivity, low noise level, and high spectral selectivity. However, the growing need of miniaturized and reliable UV detection systems for portable applications has driven the development of semiconductor-based UV PDs.

Earlier, narrow bandgap semiconductors were considered to perform UV detection. However, the very well established Si technology has some limitations in the UV region. As the bandgap of Si is 1.1 eV, so filters are needed to stop low energy photons (VIS and infrared light) and device degrades due to high energy photons in the UV range which shortens the lifetime of device. UV detectors based on wide band gap semiconductors need to be explored to avoid using optical filters, to increase efficiency, to lower noise and dark current specially above room temperature, and to achieve visible-blind operation. In addition, wide-bandgap materials are suitable for high-temperature and high-power applications due to their high thermal conductivity and breakdown field strength in comparison to Si (1.5 W/cm°C and 0.3 MV/cm, respectively), the most widely used semiconductor material for the PDs. Researchers from India's CSIR - National Physical Laboratory (CSIR-NPL) has reported a highly responsive UV PD developed using Gallium Nitride (GaN) nanoflower (NF) like structures on silicon (Si) substrate [1]. They claimed this to be the highest responsivity yield till now among the GaN UV photodetectors on Si substrates and commercially available silicon based UV photodetectors. Over Si PDs, III-Nitride based devices offer advantages such as cut-off wavelength tunability, high thermal stability, high electron saturation velocity, small dielectric constant, and high breakdown field. The GaN NFs (with avg. density of nanoflowers found to be $8.8 \times 10^7$ $cm^{-2}$) were synthesized using plasma assisted molecular beam epitaxy (PAMBE) on aluminium nitride buffered silicon (Figure 1).

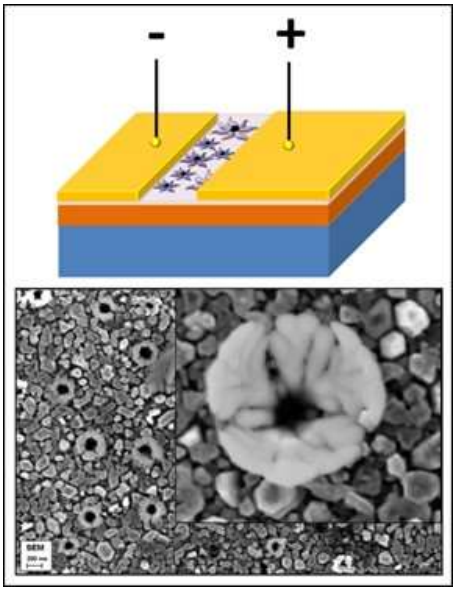


Figure 1: Schematic diagram of fabricated device and Field Emission Secondary Electron Microscopic images of epitaxially grown GaN NFs.

Upon testing the developed device under 325 nm UV light, the researcher's team experienced a stable photoresponse and its dependence on optical power is shown in Figure 2. The team achieved highest responsivity of 10.5 A/W at lower power illumination of 1mW under 1 V applied bias.

In comparison to this, planar GaN based UV PD has also been fabricated and found to exhibit a maximum photocurrent of 25.9 mA i.e. a photoresponsivity of 1.5 A/W under similar conditions.

The significant enhancement in response for GaN NFs towards UV is accredited to their higher surface-to-volume ratio, resulting in more absorption

of photons and thereby, generation of electrons and holes for current conduction.

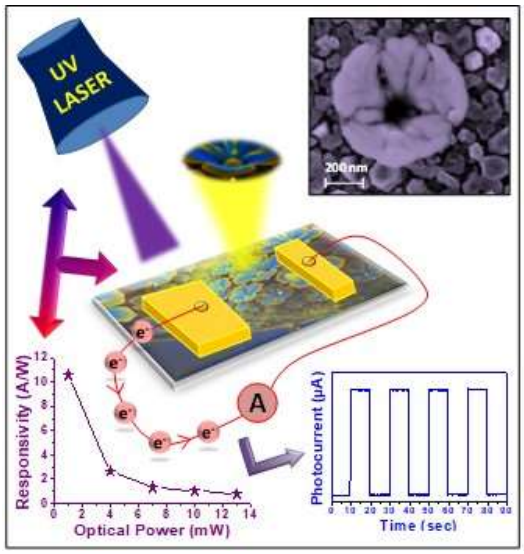


Figure 2: A layout of the GaN Nanoflowers based UV illuminated photodetection device yielding stable response and its dependence of responsivity with optical power showing highest value at 1 mW.

The planar device had a noise equivalent power of 60 pW/Hz, which is much higher than the 1.2-pW/Hz value found for the photodetectors using GaN nanoflowers. The researchers attribute the lower noise in the GaN nanoflower photodetectors to the reduction of stress and defect states. Also, they observed a photocurrent without applying any bias to the device. The responsivity at zero bias was 132mA/W at an optical power of 13mW with a very low dark current value of 90 nA. This was ascribed to the different sizes of electrodes which created a potential difference at the two metal-semiconductor junctions leading to charge transport even at zero bias.

More information about this study is given in following articles:

Aggarwal et al., *Advanced Electronic Materials,* Vol. 3, 1700036 (2017).

*Also featured in:*

*Nature India* –

*http://www.natureasia.com/en/nindia/article/10.1038/nindia.2017.56*

Nanoflowers shaped Ultraviolet photodetectors, Published online on: 25th May 2017 (doi:10.1038/nindia.2017.56) and,

*Semiconductor Today* –

*http://www.semiconductor-today.com/news_items/2017/may/csir_050517.shtml*

Ultraviolet photodetection with Gallium Nitride Nanoflowers on Silicon, Semiconductor today, Compounds & Advanced Silicon, Vol. 12, Issue 4, May/June 2017, pp-88-89.

Dr. Govind Gupta and Neha Aggarwal, CSIR – NPL, New Delhi, India

## Recent News

XIXth IWPSD (International Workshop on The Physics of Semiconductor Devices-2017) was organized during December 11-15 December 2017 at IIT Delhi by Solid State Physics Laboratory jointly with Indian Institute of Technology (IIT), Delhi in association with Society for Semiconductor Devices, Semiconductor Society (India) and Society for Information Display. Chairman ISRO & Secretary, Department of Space Shri AS Kiran Kumar formally inaugurated the event. The main objective of the workshop was to provide an international forum to deliberate and share the emerging semiconductor R&D fields in electronics; VLSI technologies, Sensors, GaN (Gallium Nitride) Materials and Devices, Crystal Growth & Epitaxy, Photovoltaics, Organic Semiconductors and Semiconductors for Quantum Computing among other. Special emphasis was given on the role of semiconductor technologies in defence, space and other civilian applications. A number of prominent Industries in the area of semiconductor R&D showcased their products along with a special industry session, mainly organized to promote 'Make in India' theme for exploring possibility of establishing semiconductor & electronics chips manufacturing in India.

Shri AS Kiran Kumar in his inaugural address emphasized the need for creating and adopting indigenous technologies. He highlighted that many of the devices used in space missions are being

fabricated at GAETEC (A DRDO unit), but the scope is tremendous.

Chairman DRDO & Secretary Department of Defence R&D Dr S Christopher presided over the function. While extending all possible help to establish the semiconductor foundry/chip manufacturing in India, he expressed the hope that the electronics chip manufacturing industries would explore the incentives under 'Make in India' and tap the huge Indian Electronics market particularly the solar power and LED lighting.

Scientific Advisor to Raksha Mantri Dr. G Satheesh Reddy stressed the need for development of navigation grade sensors, MEMs pressure sensors & accelerometers, T/R modules based on GaN technology, large format & low pitch IR detectors.

Director IIT, Delhi Prof. V Ramgopal Rao mentioned that IWPSD is the oldest international conference held in India in the area of semiconductor technology.

Many renowned scientists and technologists from USA, Europe, Asia Pacific and other countries participated in the event. Over 130 internationally acclaimed plenary/invited speakers delivered talks on research in their field of expertise. In addition, about 500 researchers from national Institutes like TIFR, NPL, IISc, IITs, NITs, CEERI etc. and other prominent Central and State universities also participated in the workshop and over 500 research papers were presented.