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The applications of surface plasmons in Ga_2O_3 ultraviolet photodetector

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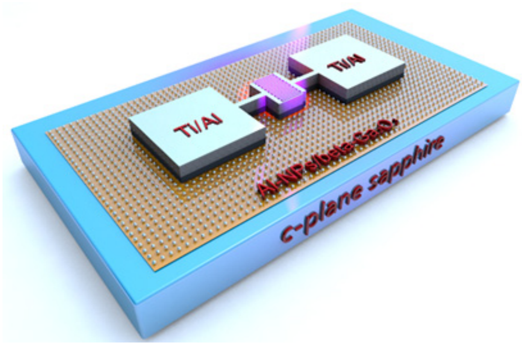

The schematic illustration of the MSM solar-blind ultraviolet photodetector

Overview: In recent years, Ultraviolet (UV) detectors have wide applications in civil and military areas, such as missile early warning systems, flame detection, environmental monitoring, optical communication and UV radiation calibration and monitoring and so on, so it has attracted considerable an amount of research interests. UV is an electromagnetic radiation with a wavelength from 10 nm to 400 nm. It is commonly subdivided into three regions: UVA (400 nm~315 nm), UVB (315 nm~280 nm) and UVC (280 nm~10 nm). However it is almost completely absorbed by the stratospheric ozone layer and can't reach Earth, and hence UVC is also named as solar-blind UV.

Many kinds of wide bandgap semiconductors, including ZnMgO, diamond, AlGaN, Ga_2O_3 (α, β, γ, δ, ε) etc., have been developed and applied on fabrication of solar-blind UV photodetectors. Among these wide bandgap semiconductor, β-Ga_2O_3 is particularly suitable for solar-blind photo-detection due to its wide band gap of 4.9 eV. In addition, β-Ga_2O_3 possesses high chemical and thermal stability. At present, it was reported that lots of high performances β-Ga_2O_3 solar-blind UV photodetector were prepared. Oshima T et al. successfully realized the growth of mono-crystal β-Ga_2O_3 thin films on c-plane sapphire substrate by MBE and metal-semiconductor-metal (MSM) solar-blind UV photo-detector. Guo et al improved performance of solar-blind UV photo-detector, such as reducing dark current, higher responsivity and sensitivity, by in situ annealing the as-grown film in oxygen atmosphere. Qian et al significantly enhanced the detectivity (D^*) of β-Ga_2O_3 solar-blind UV photo-detector by thermal-annealing pretreatment on c-plane sapphire substrates. However, in order to further reduce dark current and increase responsivity and detectivity, researchers still need to explore and perfect continually.

Recently, localized surface plasmon resonance (LSPR) supported by metal nanoparticles provides a new method to enhance the properties of β-Ga_2O_3 solar-blind UV photodetector. Noble metal nanoparticles have been widely employed in various optoelectronic devices. For instance, the properties of β-Ga_2O_3 solar-blind UV photodetector were improved by using gold (Au) nanoparticles, but Au just achieves LSPR in the visible region. Besides, aluminum (Al) can excite LSPR from 200 nm to just below 800 nm and its position of the LSPR excitation maximum is sensitive to the size, shape, inter-particle spacing, dielectric environment and dielectric properties of the nanoparticle. So Al is capable of achieving LSPR in the solar-blind region and being applied to solar-blind UV photo-detector. In this work, it is investigated that the effect on both the Al nanoparticles and the characteristics of related photodetector. It is revealed that the performance of β-Ga_2O_3 solar-blind UV photodetector with Al nanoparticles is effectively improved.

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