NASA SBIR/STTR Technologies

NASA Contract No.: NNX10CA60C, Highly Efficient FUV Photodetector with AlGaN Nanowire Photocathode

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Identification and Significance of Innovation

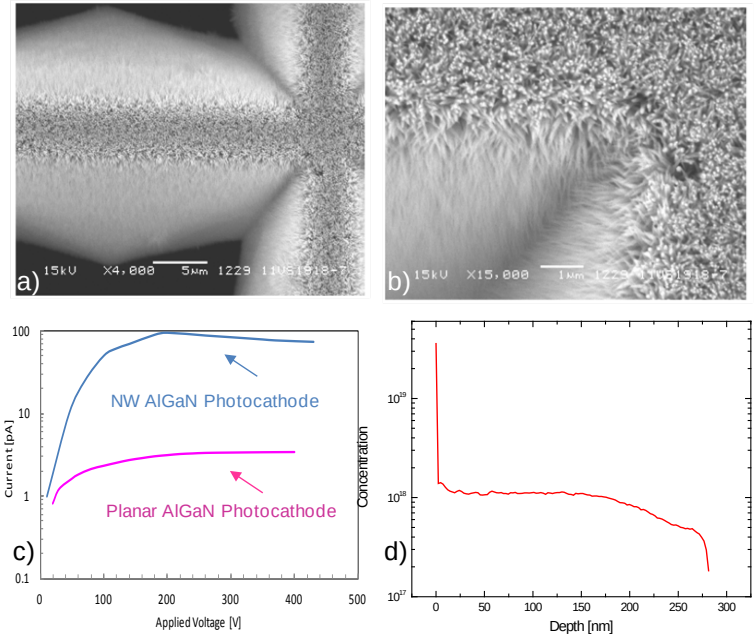
To address the NASA need for highly sensitive, large-area photodetectors for the far ultraviolet (FUV) range with long lifetime and stable manufacturing yield, Physical Optics Corporation (POC) developed technologies that allow the fabrication of a new silicon microchannel plate (Si-MCP)-based large-area (6 in. diameter) photodetectors with p++ (Mg-doped) AlGaN nanowire (NW) photocathode grown on the entrance surface of a Si-MCP (AlGaN NW-Si-MCP). POC, working in close cooperation with Technology and Devices International (TDI, Inc.), demonstrated for the first time a unique process for fabricating AlGaN NWs with a high Mg concentration near the NW surface, allowing band bending and thus facilitating negative electron affinity. It was demonstrated that the fabricated devices are 30 times more efficient than the planar AlGaN thin-film photocathodes previously demonstrated on Si-MCPs.

Technical Objectives

- Optimization of the AlGaN NW photocathode design and fabrication technology for production on flat silicon substrates.
- Demonstration of the high QE of the NW photocathodes, achievable without photocathode activation by cesiation.
- Fabrication of AlGaN NW photocathodes on the entrance surfaces of Si-MCP substrates.
- Demonstration of the high QE of NW photocathodes grown on the entrance surfaces of Si-MCP substrates.
- Investigation of the uniformity and longevity of NW photocathodes fabricated on Si-MCP substrates.
- Identification of the commercial potential of the Si-MCP photodetectors with AlGaN NW photocathodes on Si-MCP substrates.

Achievements

- Design, development, and fabrication of AlGaN nanowire photocathodes on Si-MCPs. Figures a) and b) show AlGaN NWs on Si-MCP at different magnifications.
- Development of the NW AlGaN photocathode with efficiency >30 times greater than that of the planar AlGaN film photocathode (Figure c).
- Development of a new, unique process to fabricate a high concentration of Mg near the surface of the AlGaN NWs: 4×10^{19} cm^3 Mg, suggesting that band bending conditions facilitate negative electron affinity (Figure d).
- Demonstration for the first time of the growth of AlGaN NWs on thin metal films and realizing nanoscale heterostructures with properties engineered by design for AlGaN material.
- Establishment of a robust procedure for the fabrication of 6-in. Si-MCPs with various pitches using a completely automated etching setup showing a clear pathway for the cost-efficient fabrication of Si-MCP structures with high yield.



NASA Applications

FUV telescopes and spectrometers for future missions within the Explorers, Origins, and Beyond Einstein Programs, and Discovery Office. Current and future missions that rely upon this technology include HST-STIS, GALEX, COS, EUVE, XMM-OM, CHIPS, and FAUST. The AlGaN NW-Si-MCP photodetectors offer higher sensitivity, lower background noise (lower probability of interaction with gamma rays), larger size, windowless operation, and better spatial resolution.

Non-NASA Applications

Novel FUV optoelectronic devices (including more efficient LEDs with tailored light emission wavelengths), missile plume detection, non-line-of-sight covert communication, atmospheric research, biosensors, and machine vision. POC-developed AlGaN NW heterostructures can greatly benefit the semiconductor community by supporting the realization of novel radio frequency (RF) high-power transistors and microwave power amplifiers.

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NON-PROPRIETARY DATA