PROJECT SUMMARY

Under this NASA Phase II SBIR project, Physical Optics Corporation (POC) developed technologies for fabrication of new silicon microchannel plate (MCP)-based large-area photodetectors for the far ultraviolet (FUV) range, with long lifetimes and stable manufacturing yields based on p^{++} (Mg-doped) AlGaN nanowires (NWs) 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. of Silver Spring, Maryland) demonstrated fabrication of large (6 in. diameter) silicon MCPs with an AlGaN NW FUV-sensitive photocathode deposited on both the front surface and the microchannel walls. The fabricated devices demonstrated efficiency increased more than 30 times, compared to the planar AlGaN thin-film photocathodes previously demonstrated on Si MCP.

POC designed and developed an innovative manufacturing process for a new AlGaN NW-Si-MCP with a highly efficient NW AlGaN photocathode with negative electron affinity, fabricated directly on the surface of a silicon microchannel substrate. This development was based both on POC's light-assisted electrochemical anisotropic etching (ECANE) process for large-area Si-MCPs, in which the photolithographic mask defines the microchannels, and on the development of new innovative processes in collaboration with our subcontractor, TDI, Inc. We have established the process and, **for the first time,** demonstrated AlGaN NW growth on thin metal films. The process developed was proven on planar Si substrates with thin Au film (150 nm) deposition, as well as on oxidized and nonoxidized Si-MCPs covered with gold. Such an advance can have a beneficial impact not only photodetection applications but on the semiconductor industry, which will acquire a novel, efficient, fabrication process for nanoscale high-power transistors and novel UV optoelectronic devices. POC has also developed a **novel, unique process to fabricate AlGaN NWs with high Mg concentrations near the surface** by abruptly stopping the flow of gases containing Al and Ga but continuing to allow Mg to flow into the reactor for a short period of time. Mg concentrations enhanced by an order of magnitude within a few nanometers of the surface, as compared to the bulk material, have been demonstrated. This discovery allows us to produce band bending on the NW surfaces, thus facilitating negative electron affinity. POC established a robust procedure for fabrication of 6 in. Si-MCPs with various pitches, using a completely automated etching setup with the capability to process two wafers simultaneously. This automated etching station allows fabrication of Si-MCP structures with high yield in a cost-efficient way. The expertise we gained working with the current etching station suggests that costs of the Si-MCP fabrication can be easily reduced with extension to higher volumes.

In contrast to the conventional AlGaN thin-film photocathode, which requires activation by cesium or oxygen ions, the AlGaN nanowire photocathode developed has a built-in surface electric field due to the NW morphology; in addition, the innovative doping procedure leads to negative electron affinity. The photocathode developed will operate efficiently in open space for a long time without any need for cathode activation. This innovative windowless FUV photodetector supports new research opportunities for NASA by extending the spectral coverage to the FUV range and offering significant improvements in overall instrumentation throughput due to its high quantum efficiency. The technology developed will benefit future NASA missions within Explorers, Origins, Beyond Einstein, and Discovery Office Programs. Non-NASA applications of AlGaN NW-Si-MCP include missile UV optoelectronics, nanoscale high-power transistors, other semiconductor applications, plume detection, non-line-of-sight covert communication, atmospheric research, biosensors, and machine vision.