Developing Quanta Image Sensor for UV Photon Counting Detectors in Space Applications

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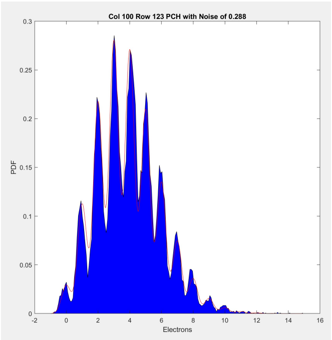
Program: FY21 R&TD Topics **Strategic Focus Area: Remote/In Situ/Life Detection Sensors and Instruments**

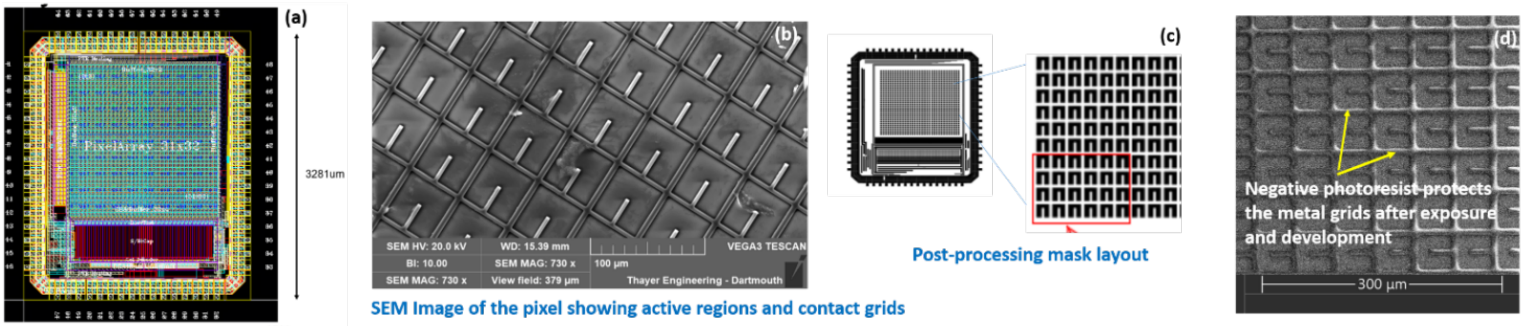
Objectives: The objective of this effort was to develop a novel approach to low dark current, radiation tolerant, ultraviolet single photon-counting detectors as a critical component of space astrophysics and planetary science instruments. This combines complementary expertise at JPL and Dartmouth Thayer School of Engineering by ultraviolet enhancement of quanta image sensors (QIS) using 2D doping and NP processing.

Background: Recently, final reports of four flagship mission studies funded by NASA were submitted to the Astrophysics Decadal Survey. Large Ultraviolet/Optical/Infrared Surveyor and the Habitable Exoplanet Observatory concepts have multiple instruments that crucially depend on ultraviolet (UV) photon counting detectors. We use these concepts' requirements in photon counting, quantum efficiency (QE), dark current, etc. as development guidelines, but all classes of astrophysics missions as well as Planetary sciences and Heliophysics missions– could benefit from this development.

Approach and Results



A typical photon counting histogram at room temperature showing visible photon counting operation of the camera.



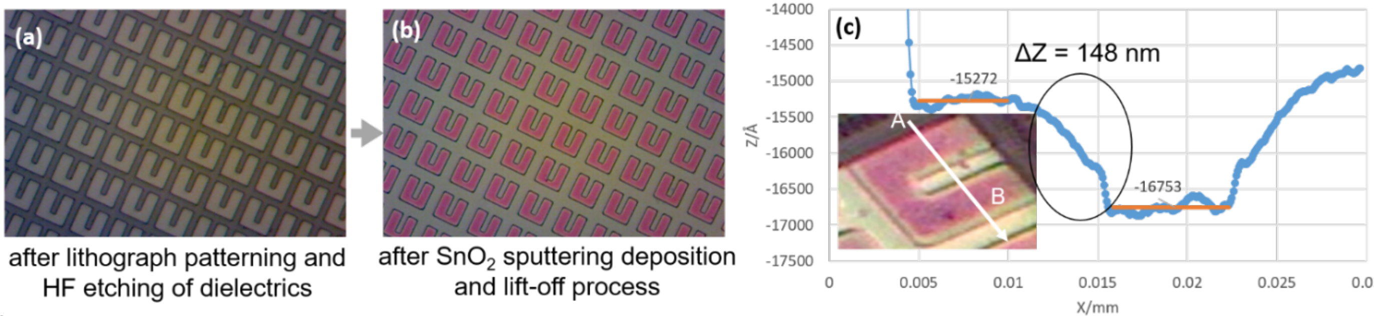
SEM Image of the pixel showing active regions and contact grids

Post-processing mask layout

(a) Layout of a large-pixel Si CIS test chip for NP structure process (b) top-view SEM image of the Si CIS pixels and metal contact grids. (c) photomask pattern to open "U" shape windows to the Si pixel regions, protecting the metal grids. (d) example of Si CIS chips after contact mask photolithography and development. Some charging effect observed due to the photoresist covering and protecting the metal contact grids during dielectric etching

Significance/Benefits to JPL and NASA

The UV QIS will have low dark current (no avalanche gain), high QE, tailorable spectral response, no high operating voltages unlike microchannel plates (MCPs), is expected to be radiation tolerant. All characteristics that would benefit future NASA missions in science return and risk.



after lithograph patterning and HF etching of dielectrics

after SnO_2 sputtering deposition and lift-off process

Optical microscopy images of (a) a test chip after lithography patterning and HF etching of dielectrics (b) after SnO_2 sputtering and lift-off process. (c) Profile along A-B cross-section (profilometry). The thickness of the SnO2 is ~148 nm, in good agreement with expected model of 150 nm.

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Clearance Number:
RPC/JPL Task Number: R21125