National Aeronautics and Space Administration

TRL Advancement and Qualification for UV and UV/Optical Photon Counting & Scientific Silicon Detector Arrays

Principal Investigator: Shouleh Nikzad (389); Co-Investigators: John Hennessy, Michael Hoenk, April Jewell

Program: FY21 R&TD Strategic Initiative **Strategic Focus Area: UV Spectroscopy**

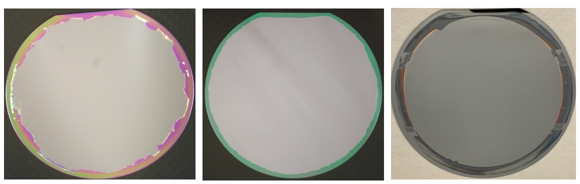
Objectives and Background: The objective of this R&TD effort was to create, characterize, and environmentally test a statistically significant number of high efficiency ultraviolet (UV) scientific detectors in order to qualify UV detector technologies for future missions. Through this effort and in collaboration with Teledyne-e2v, we will develop optimized processes for scientific UV detectors, establish a high-fidelity yield, and qualify the end-to-end post fabrication processing of high-performance UV/Optical detectors. JPL applies unique surface nanoengineering processes—in batches—to two Teledyne-e2v wafer types, comprising standard CCDs similar to the flight-qualified detectors for the Euclid Space Telescope, and electron multiplying CCDs (EMCCDs) similar to the detectors currently being qualified for the Roman-CGI. By teaming with Teledyne-e2v, a leading manufacturer of scientific CCDs for spaceflight, we aimed to advance and certify the end-to-end processes required for producing ultraviolet CCDs with unique performance and capabilities for future NASA missions. By the end of this strategic initiative task, JPL and Teledyne-e2v will have fabricated, processed, and tested a number of detectors and performed the performance evaluation and environmental testing necessary to qualify the post fabrication processing for devices encompassing the range of pixel architectures and readout structures in Teledyne-e2v's scientific detector product lines.

Approach and Results

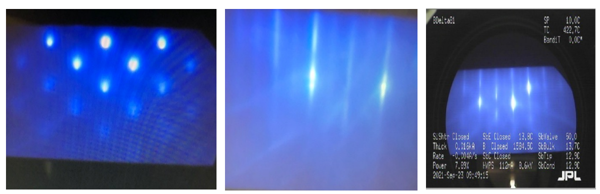
First batch of four wafers from each type of device, i.e., EMCCD (CCD201) and Large Format CCD (CCD272) went through the entire end-to-end process flow.

Feedback from Te2v received in the six weeks of the year. Feedback was in the from visual inspection, DC probe, image probe, voltage shift tests, and relative quantum efficiency (QE) measurement. The DC and image probe data revealed a problem that had occurred (determined after multiple and various testing and process reviews) during the planarization steps in bonding. This caused a number of opens in the devices. Root cause has been identified, it will be verified and corrected.

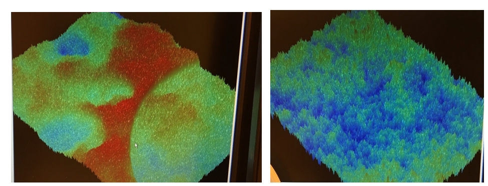
Relative QE measurements at probe level reveals that 2D process is performing as expected.



Processes were developed and verified to improve bond strength and reduce the risk of delamination during thinning. Left: previously processed Teledyne-e2v CCD wafer starting to delaminate after bonding and coarse thinning. Middle: Bonded and thinned using optimized processes developed in this task, leading to significant improvement after bonding and coarse thinning. Some delamination still observed after fine thinning step, which led to the "edge trim" process step resulting in further improvements in the robustness of the bonding step.



Reflection High Energy Electron Diffraction (RHEED)—an in situ tool for a wafer inside the MBE machine (for 2D doping). The RHEED pattern is formed on a screen after a beam of electrons grazes the surface of the wafer. Left is a typical "bad" RHEED indicating a rough surface unsuitable for successful MBE while the middle figure shows a smooth set of lines indicating a smooth silicon surface that is ready for MBE growth. Right: good RHEED pattern from a sample that experienced all the sample preparation steps that lead to the 2D doping in the MBE. RHEED in only done on "witness" samples and not live devices.



Surface topography (roughness) as measured by optical interferometry using MDL's Veeco Wyco apparatus. Left: a rough surface unsuitable for delta doping due to uneven and aggressive etching. Right: Surface after a series of preparation and etches that leave the surface clean, smooth, and suitable for delta doping.

Significance/Benefits to JPL and NASA: High performance, high efficiency ultraviolet and ultraviolet CCDs that are mature and reliable in fabrication increases the chance of success in future mission proposals and missions. Achieving certification/qualification of our end-to-end post fabrication processes with Te2v CCDs provides justification of having high fidelity prototype for virtually all of delta doped Te2v CCDs on their product line –some baselined for Explorer mission concepts.

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
www.nasa.gov

PI/Task Mgr Contact
Email: Shouleh.Nikzad@jpl.nasa.gov

Clearance Number:
RPC/JPL Task Number: R19038