NASA SBIR/STTR Technologies

S1.01-8246 - Low-Noise Analog APDs with Impact Ionization Engineering and Negative Feedback

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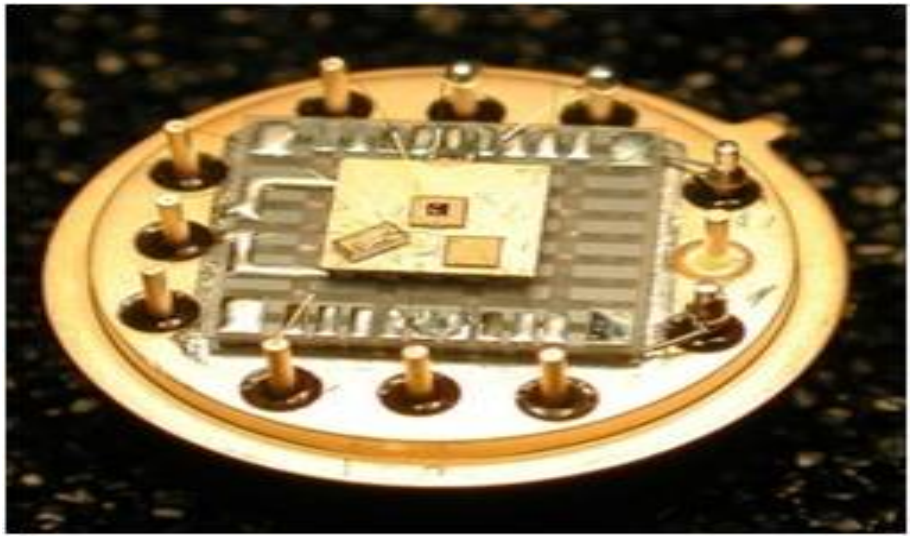
Identification and Significance of Innovation

Future NASA LIDAR missions require low noise and large area photodetectors operated at short-wave infrared (SWIR) wavelengths. Silicon avalanche photodiodes have very low responsivity for wavelength longer than 1.1 um; and while InP-based APDs have high responsivity in the SWIR region, they exhibit high noise equivalent powers (NEPs) due to the relatively high excess noise of bulk InP multiplication regions. We propose to develop low-noise analog APDs operating in the SWIR region by incorporating impact ionization engineered structures coupled with a negative feedback mechanism into the multiplication region of linear mode APDs. The goal is to develop large-area (>250 um diameter), low-noise SWIR detectors with high quantum efficiency (>75%), high bandwidth (~100 MHz), and very low NEP approaching NASA targets of 20 fW/rt(Hz). In addition to discrete device characterization, these devices will be incorporated into prototype LIDAR receivers for performance assessment.



Estimated TRL at beginning and end of contract: (Begin: 2 End: 3)

Technical Objectives and Work Plan

Technical Objectives:
I. Analytically develop analog APD device structures that have low excess noise factor, low NEP, high quantum efficiency and high stable gain through impact ionization engineering and negative feedback.
II. Perform epitaxial wafer growth and device fabrication to verify the design concept and deliver prototypes for NASA scientists to evaluate the novel analog APDs.

Work Plan:
Task 1. Epitaxial design
Task 2. Device layout and photomask design
Task 3. Epitaxial wafer growth and characterization
Task 4. Wafer processing and device fabrication
Task 5. Chip-level device characterization and data analysis
Task 6. Assembly of prototypes for delivery to NASA
Task 7. Device design and process flow definition for manufacturability

NASA Applications

+ Active remote sensing optical instruments (LIDAR) for NASA programs such as ASCENDS, ACE and Doppler Wind Lidar
+ Free-space optical communications

Non-NASA Applications

+ Range-finding and ladar applications
+ Commercial lidar systems
+ Optical time domain reflectomery (OTDR)
+ Free-space optical communications

Firm Contacts

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NON-PROPRIETARY DATA