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Title: Reliability evaluation of the integrated photonic receiver subsystems with all-optical signal processors

Summary

Objectives: We propose to evaluate the packaging stability and sub-system level reliability of the integrated photonic receivers, including machine learning designed photonic accelerators and hybrid ultrafast photodetector arrays. The germanium integrated silicon photonic detector arrays are widely adopted in optical interconnects, given their superior performance and CMOS nanomanufacturing compatibility. Those integrated photonic receivers are light-weight and low power alternatives to the fiber-based ones used in space communication and remote sensing missions.

Methods: The purpose of this research effort is to improve the technology readiness level of the photonic integrated circuit (PIC) based receiver subsystems. We will exam the optical fiber packaging stability and reliability in the acceleration of rocket lunching and the microgravity environment on the international space station (ISS). As a part of the communication instrument installed on the external part of airborne or spaceborne craft, those integrated photonic componentsradiation hardness will be evaluated by installing the PIC component in the Materials on the International Space Station Experiment (MISSE).

Significance: The proposed silicon photonic metasurface platform can benefit the space communication and earth science measurement through (1) reduction of significant reduction in size, weight, and power (SWaP) through replacing the fiber based and/or free-space adaptive optic system with correspondent on-chip photonic circuits; (2) increasing mechanical robustness by eliminating any moving parts; (3) significant data reduction. The PIC photonic accelerator/pre-processor can extract spatial and spectral key information from the datasets in temporal and spatial domains. Only those key information needs to be converted into electronic format for storage or further processing.

Contributions to NASA: Currently, the PIC product development in aerospace applications focuses on reliability, efficiency, and lifetime. The device performance and stability evaluation on MISSE will addresses those concerns. The proposed photonic components and subsystems potential impact on remote sensing missions and optical communication missions operating on low earth orbit, such as Laser Communications Relay Demonstration Mission and Earth Science Observation Missions on ISS.

The proposed technology aligns with NASA Strategic Goals: Planned communication development of new technologies, such as optical communications, & (Strategic goal 4.2); and using optical and radar techniques to better understand objectsorbits, shapes, sizes, and rotation states. (Strategic Objective 1.1). The proposed integrated photonic components contribute to the major critical technology investments Scientific Instruments, Sensors and Optical Communications. The proposed on-chip receiver subsystem belongs to Technical area 5.1.7 Integrated Photonics (Critical Near-Term), enabling low SWaP implementation of receiver technology in "atmospheric sounding and light detection and ranging (LIDAR)" and optical communication. The component with manifested data rate matches the demand of &higher data rates from the instrumentation and sensors carried on NASA science missions and to ensure safe, timely, effective mission operations.