Photonic-Electronic Advanced Computing with Heterogeneous Integration for Space-based Environments

Adam Slater, University of Virginia, School of Engineering and Applied Science, Charlottesville, VA
Steven M. Bowers, University of Virginia, School of Engineering and Applied Science, Charlottesville, VA

Abstract

Computing performance is severely limited in space-based applications. Ground-based computing speeds are 1000 times greater with efficiencies nearly 2 times greater. This work details how to improve space-based computing using photonic-electronic hardware. This includes photonic computing architecture design and analysis, electronic interface design and test, and system design. The proposed system employs vertically stacked heterogeneous integration, where electronics and photonics are directly connected chip to chip, enabling peak performance with minimal volume. The most energy-intensive components are in the electronic interface. To reduce power consumed in the electronic interface, a novel digital-to-analog converter is designed and tested demonstrating an efficiency of 95fJ/bit, a 10x improvement over state-of-the-art. This work provides a roadmap to reduce computing energy consumption below 100fJ/operation at speeds exceeding $1 \cdot 10^{15}$ operations per second for space-based computing.