Title: 3D Nucleic Acid Memory Readout Using SPAD-Enabled Fluorescent Lifetime Imaging Microscopy

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Abstract:

Global digital data generation surpasses 120 ZB per year, so the demand for innovative data storage solutions is imperative. DNA-based memory is an appealing solution due to its exceptional data density, stability, and energy efficiency but it lacks a robust and scalable readout scheme. To work toward this challenge, we propose a novel DNA memory approach where DNA is used as a self-assembled, structural material to store data in three dimensions with nanometer precision and readout optically in parallel rather than through sequencing. Here, we present an imaging system that localizes fluorescently-tagged DNA in 3D through a combination of fluorescent lifetime and super-resolution microscopy. The system is comprised of a custom 16x16 single-photon avalanche diode (SPAD) array developed in a 180nm CMOS process with multiplexed photon processing for frame rates up to 80MHz. For photon timestamping, we designed a tapped delay line time-to-digital converter (TDC) with 18 ps resolution and a linearity of -0.4/+0.2 LSB. We implemented 16 parallel TDC channels on the Xilinx Zynq 7000 SoC for high-throughput lifetime readout. Next, we will integrate our imager into a microscope to image DNA storage nodes.

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