16th International Workshop on
Low Temperature Detectors
20–24 July 2015

# Arrays of WSi Superconducting Nanowire Single Photon Detectors

**Main author:**

BEYER Andrew

**Co-authors:**

Bardin Joseph, University of Massachusetts, Amherst MA 01003-9292, USA

Beyer Andrew, Jet Propulsion Laboratory (JPL), California Institute of Technology, Pasadena, CA 91109 USA

Chang Su-Wei, University of Massachusetts, Amherst MA 01003-9292, USA

Farr William, Jet Propulsion Laboratory (JPL), California Institute of Technology, Pasadena, CA 91109 USA

Gin Jonathan, Jet Propulsion Laboratory (JPL), California Institute of Technology, Pasadena, CA 91109 USA

Marsili Francesco, Jet Propulsion Laboratory (JPL), California Institute of Technology, Pasadena, CA 91109 USA

Mirin Richard, National Institute of Standards and Technology, Boulder, CO 80305, USA

Nam Sae Woo, National Institute of Standards and Technology, Boulder, CO 80305, USA

Patawaran Ferze, Jet Propulsion Laboratory (JPL), California Institute of Technology, Pasadena, CA 91109 USA

Ravindran Prasana, University of Massachusetts, Amherst MA 01003-9292, USA

Resta Giovanni, Jet Propulsion Laboratory (JPL), California Institute of Technology, Pasadena, CA 91109 USA

Russell Damon, Jet Propulsion Laboratory (JPL), California Institute of Technology, Pasadena, CA 91109 USA

Shaw Matthew, Jet Propulsion Laboratory (JPL), California Institute of Technology, Pasadena, CA 91109 USA

Stern Jeffrey, Jet Propulsion Laboratory (JPL), California Institute of Technology, Pasadena, CA 91109 USA

Verma Varun, National Institute of Standards and Technology, Boulder, CO 80305, USA

Superconducting nanowire single-photon detectors (SNSPDs) [1] based on tungsten silicide (WSi) have demonstrated excellent performance at 1.55 μm wavelength (λ), with ~ 93 % system detection efficiency (SDE), ~ 1kcps background photon count rate (BPCR), ~ 150 ps FWHM jitter, and reset times of tens of nanoseconds [2]. Here we report on the development of 64-pixel free-space-coupled arrays of WSi SNSPDs designed for the ground receiver of a deep-space optical communication system. By reading out 16 of the 64 pixels, we achieved SDE = 36 %, BPCR ~ 40 kcps, jitter of ~ 150 ps FWHM, and maximum count rate of 38 Mcps.

The active area of the array was a 160 μm x 160 μm square. The array was composed of 2 x 32 contiguous pixels, each covering a rectangular active area of 80 μm x 5 μm. The nanowires were 160 nm wide and the nanowire pitch was 500 nm. The array was embedded in an optical stack, which was designed to maximize the absorption in the WSi at λ = 1.55 μm [2]. The array was mounted in a cryostat with a 2 in-diameter optical window and operated at ~ 500 mK. The output of the 16 of the 64 pixels was preamplified with cryogenic amplifiers and logically ORed with cryogenic channel combiners, which digitized the inputs at a clock rate of 6.4 GHz. The cryogenic electronics was mounted on the 40 K stage of the array cryostat. A 1.537 μm-wavelength CW diode laser was free-space coupled to the array through cryogenic optical windows.

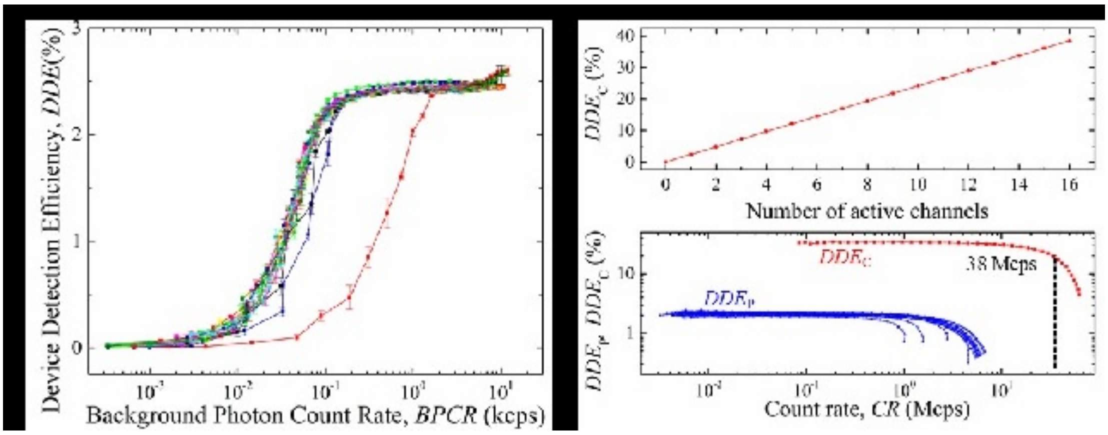

Figure 1a shows the single-pixel DDE (DDEP) of the 16 pixels under uniform illumination as a function of BPCR. The DDEP vs BPCR curves show an inflection point and begin to saturate to DDEP = 2.45 ± 0.05% for BPCRP approaching 500 cps (only one pixel shows a different behavior saturating for BPCRP ~ 2kcps). Based on the results reported in Ref. [2], we expect the BPCRP to be due to blackbody photons. By improving the filtering of the blackbody radiation, we expect to reduce the BPCRP by two orders of magnitude. Figure 1b shows the combined DDE (DDEC) as a function of the number of combined channels (N). With 16 combined channels, we achieved SDEC ~ 38 %. Figure 1c shows the dependence of DDEP and DDEC on the count rate (CR). We defined the maximum count rate (MCR) of our detector system as the response count rate at which the system detection efficiency was suppressed by 3 dB with respect to the low-count-rate value. With 16 combined pixels MCR reached 38 Mcps.

Based on these results, we expect the full 64-pixel array to achieve MCR ~ 200 Mcps, SDE > 50% and BPCR