Lumped-element aluminum KIDs with hierarchical phased-array antennas

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***Abstract*—We have developed lumped-element aluminum kinetic inductance detectors (KIDs) for millimeter and submillimeter wavelengths. The incoming light is received with a hierarchical phased-array of slot-dipole antennas, split into four frequency bands (between 125 GHz and 365 GHz) with on-chip lumped-element band-pass filters, and routed to different KIDs using microstriplines. The antenna far-field beam-pattern, band-pass filter spectral response, and noise equivalent power were characterized and we report on these results.**

***Keywords*— aluminum, hierarchical antenna, KID, kinetic inductance detector, superconductor, THz.**

I. Introduction

For studies of the Sunyaev-Zeldovich effect, the cosmic microwave background, and dusty sources, future large-aperture ground-based telescopes would benefit from detectors able to observe simultaneously several spectral bands between 75 GHz and 415 GHz. By coherently summing signals from multiple individual pixels, hierarchical antennas are able to scale the pixel size with the observed frequency, allowing the coverage of a very wide frequency range while keeping a constant beam size, as demonstrated by Cukierman et al. [1]. The use of hierarchical antennas in combination with band-pass filters would allow the simultaneous observation of multiple frequency bands within the antennas frequency range.

II. Design

We initially designed a three-scale hierarchical phased-array slot-dipole antenna concept, designed to be coupled to titanium nitride KIDs, covering 75–415 GHz [2], and we designed and fabricated a two-scale version with four bands covering 125 GHz to 365 GHz, coupled with aluminum lumped-element KIDs [3]. The incoming light received through the two-scale hierarchical phased array of slot-dipole antennas is summed via superconducting microstriplines, and routed through superconductive microstripline and banks of band-defining filters to lumped-element aluminum KIDs. The microstripline uses hydrogenated amorphous silicon dielectric to ensure good transmission into the submillimeter, and the same dielectric is used in parallel-plate capacitors for the KIDs to achieve low loss, low noise, and low susceptibility to direct absorption. A schematic of the hierarchical phased-array antennas with the band-pass filters is shown in Fig. 1.

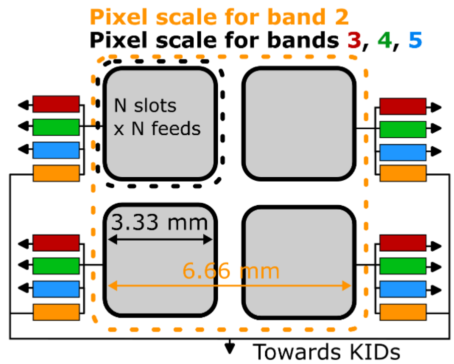

Fig. 1. Schematic of the hierarchical phased-array antennas. The N slots of each pixel are coherently summed using microstriplines. Each pixel is connected to lumped-element band-pass filters corresponding to bands 3, 4, and 5, while the four pixels are coherently summed together and connected to the band-pass filters defining band 2.

We report on the characterization of the 2-scale hierarchical phased-array antennas, on the spectral response of the 4-band lumped-element band-pass filters using Fourier Transform Spectroscopy, and on the noise-equivalent power of the KIDs.

References

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