Towards 100% array yield: understanding (and fixing) the causes of KID array inhomogeneity

Johannes Goupy[1,2], Shibo Shu[1], Martino Calvo[2], Alessandro Monfardini[2], Samuel Leclercq[1], and Eduard F.C. Driessen[1]

Kinetic Inductance Detectors (KIDs) have been proven to be an interesting technology for continuum detection from the mm-wave to infrared frequencies. Their intrinsic multiplexibility makes the fabrication of large arrays relatively simple, and a number of instruments have shown high quality performance on telescope, while many more instruments employing this technology are being developed.

A major challenge in fabricating large KID arrays is the frequency scatter of individual detectors, due to fabrication imperfections. This frequency scatter inevitably causes cross talk when two pixels get too close in resonance frequency. This problem can be mitigated at the expense of increasing the available frequency bandwidth per pixel, but this approach significantly limits the possible number of pixels, and is therefore not preferred especially when readout bandwidth is a scarce resource.

In a previous contribution, we have shown that the frequency scatter of a small KID array of 100 pixels can be repaired by a post-characterization adaptation of the on-chip capacitors. Here we will show that this technique can be extended to 2000-pixel telescope class arrays [2], with marginal loss of efficiency. A detailed mapping of the dimensions of 800 pixels shows that the frequency scatter for this 80-mm array is most impacted by the lateral variations of the width of the inductor lines (up to 20% variations).

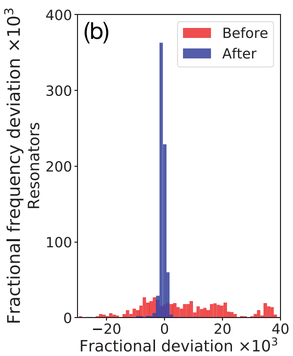

Figure 1 - Fractional frequency deviation of a telescope-class KID array before (red) and after (blue) trimming the on-chip capacitors. A more than 10x improvement of the frequency spread can be obtained.

[1]Institut de Radioastronomie Millimétrique, 38400 St Martin d'Hères, France; [2]Institut Néel, UGA and CNRS, 38000 Grenoble, France

Although the frequency scatter can be repaired by our technique, the width variation of the inductor line also causes a variation in pixel sensitivity, which cannot be as easily repaired. In a second part of our contribution, we will therefore focus on the underlying causes for the inhomogeneity itself. We will show that the width variations are due to an inhomogeneity in the wet etching of the aluminium film. We will show pathways to attack the inhomogeneity at its source and show the prospects for telescope class arrays.

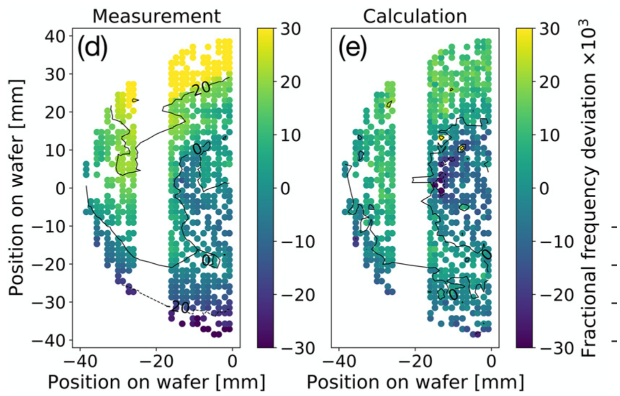

Figure 2 - Resonator frequency shift as measured (left) and calculated (right) from measured resonator dimensions.

References

[1] S. Shu et al., "Increased multiplexing of superconducting microresonator arrays by post-characterization adaptation of the on-chip capacitors", *Appl. Phys. Lett.* **113**, 082603 (2018).

[2] S. Shu et al., "Understanding and minimizing resonance frequency deviations on a 4-in. kilo-pixel kinetic inductance detector array", *Appl. Phys. Lett.* **119**, 092601 (2021),

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