Development of large array of Kinetic Inductance Detectors using commercial-level foundry

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Introduction
Evolution of CMB experiments
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Photomask is designed to check the performance of new process and basic performance of kids fabricated on MEMS processes. 15 types of 20 \( \mu \text{m} \times 20 \mu\text{m} \) chips are designed. The KIDs consists of coplanar waveguide (CPW) feed line and \( \lambda/4 \) CPW resonators. The dimension of the feed line is designed to be \( g_f = 3 \mu\text{m} \), \( w_f = 5 \mu\text{m} \). So its impedance is set to be 50 \( \Omega \) in all chips. Resonators are categorized into 9 section and there are frequency gap between each section. Parameter is set to each section.

Measurement setup
Dilution refrigerator, an Oxford I0, is used to produce operational temperature of KIDs. The temperature of KIDS is measured and controlled using an AC resistance bridge (LakeShore 372) with Ruox sensor. CuNi coaxial wires are employed for thermal isolation. Two 20dB fixed attenuators are installed in 1K and 3K stages to minimize the noise.

Conclusion
We demonstrated the KIDs fabricated on a 6-inch wafer and an 8-inch wafer using commercial-level MEMS process. Measurement setup using dilution refrigerator is prepared to develop the KIDs for next generation experiments. Measured results look comparable to the KIDs fabricated on a dedicated cleanroom and is very promising to realize the large array of KIDs.

Fabricated 6in and 8in KIDs
Designed KIDs are fabricated by commercial-level MEMS foundry to fabricate KIDs on large diameter wafers. Simplest single layer Aluminum KIDs are fabricated as a first test. MEMSCORE fabricated on a 6-inch FZ wafer and MNOIC fabricated on an 8-inch MCZ wafer. Oxidation(SiOx) layer is removed by HF solution. Aluminum is sputtered 50 nm and 100 nm to study the thickness dependency. KIDs patterns are exposed using aligner. Aluminum layer is processed by wet etching process. The advantage of MEMS process is availability of Niobium which has a \( T_c = 9 \)K (\( \sim 300 \)GHz) is very useful for several application including CMB observation. We will fabricate Nb-KIDs in next fabrication.

Results
A test chip fabricated in an 8-inch process is measured. The thickness of Al was 130 nm. Sharp resonances are observed in a designed frequency range of 4 GHz – 8 GHz. And the resonances are disappeared above Tc of aluminum (\( T_c = 1.2 \) K).

We can identify the resonator on chip which create a peak on a transmission curve thanks to the frequency gap between the categories and wide frequency distribution.

Quality of the resonator is expressed by quality factor (Q) of resonator. Quality factor is defined by stored energy over power loss and can breakdown to internal quality factor (Q) and coupling quality factor(Qc). Qc is controlled by design. 

\[
Q = \frac{(\omega\Delta f_{core})}{\Delta f_{loss}} = \frac{1}{Q_c} + 1/Q_i
\]

Observed resonances are fitted using Gao's function[5] to extract parameters. Fit result of resonances at 6.49 GHz is shown. Temperature response is measured by controlling the temperature of mixing chamber. Fit result of resonances at 6.49 GHz is shown.

Fitting is well performed, and the result well reproduced the data. \( \chi^2/ndf = 1.2 \) Extracted Q was 150,000 and coupling quality Qc was 40,000.

Conclusion
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