A demonstration of cryogenic trans-impedance amplifier using fully-depleted silicon-on-insulator CMOS operational amplifier for far-infrared image sensor

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Abstract
We are developing a low power cryogenic readout integrated circuit (ROIC) for large format far-infrared image sensor. As cryogenic electronics, we use fully-depleted silicon-on-insulator (FD-SOI) CMOS technology. FD-SOI MOSFETs show very stable static characteristics at 4.2 K. We report the trans-impedance amplifier (TIA) circuit using FD-SOI CMOS OPAMP at cryogenic temperatures. In order to evaluate performance in measuring current for the TIA circuit, we combined the TIA circuit with the germanium blocked impurity band (Ge-BIB) detector as very small and calibrated current source.

Introduction
- Our goal is large format far-infrared image sensors
- Ge-BIB detectors + cryogenic electronics
- Conventional bulk CMOS shows anomalous behavior
- Fully-depleted SOI CMOS shows very stable static characteristics under 4 K.

Cryogenic readout electronics using FD-SOI CMOS
- We successfully developed a cryogenic operational amplifier (OPAMP).
- We will design TIAs and CTIAs for measurements of ultra-low current (~fA).
- Low power consumption
  - large format
    - a few mW for 32 x 32 pixels (1uW/pix)
  - low background
    - no need to warm up
  - High gain
    - suitable for feedback circuits

A demonstration of trans-impedance amplifier
- Operation under 4 K.
- Measurement of ultra-low current(fA)
- Ge-BIB detector as very low and calibrated current source.
  - an intrinsic Ge + a Ge doped Ga of 1E+16/cc

Result
- Output 32mV@Bias 0.1V ~ 300fA

Next step
- We will measure dark current 1fA at 1.8 K.
- In addition, We will evaluate the image sensor of 5 x 5 pixels.