Carbon Absolute Electrical Substitution Radiometers (CAESR)

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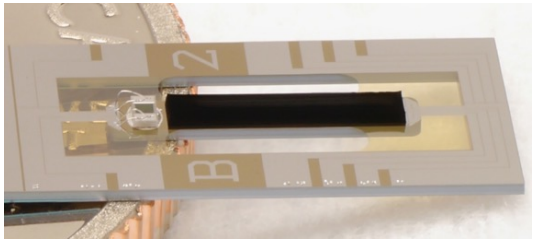
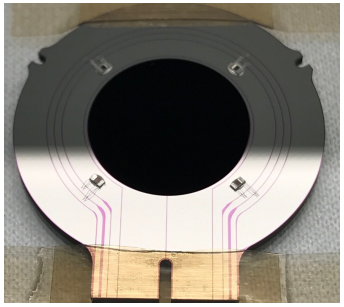
Objective

- Develop compact, ambient-temperature electrical substitution radiometers (ESRs) using vertically-aligned carbon nanotube (VACNT) silicon bolometers for solar-irradiance applications:
  - Using integrated fabrication involving photolithography, metal deposition, VACNT growth, and micromachining on single wafer
- Develop two ESR types for measuring solar irradiance:
  - Total Solar Irradiance: Input Power ~40 mW
  - Spectral Solar Irradiance: Input Power ~40 μW



CSIM ESR
Launched 2018-12
Still in operation
Noise Level ~160 pW



CTIM ESR
Planned Launch 2021-12
Noise Level ~55 nW

Accomplishments

- Developed and fabricated multiple ESRs and tested them versus TSIS-1 state-of-the-art radiometers.
  - The performance of CSIM ESR is measured to be 0.16 nW as compared with the TSIS-1 SIM ESR of 2.08 nW for a 60s measurement.
- Collaborated with NIST to add Carbon Nanotubes to the ESR increasing the solar-weighted absorption of compact total solar irradiance monitor (CTIM) detectors to 99.9945% as compared to 99.9595% for the TSIS-2 TIM detectors.
- Improved the manufacturability of the detectors from a previous 25% yield / 12-month production time to a >60% yield / 4-months production time
- Incorporated a fully calibrated CNT-based ESR on CSIM for a flight demonstration in space and it has performed for over two-years on-orbit, has taken more than 30 solar spectra for calibration of the on-board photodiodes, provided an independent validation of the TSIS-1 SIM measured solar spectra, and provided measurements from 2365 to 2730nm for a new reference solar spectrum.
- A fully calibrated ESR will be the basis for the CTIM InVEST program aimed at demonstrating total solar irradiance (TSI) continuity measurements from a 6U CubeSat platform.
- ESR work has enabled array development for many future Earth science applications and are base-lined as the detector for the BABAR-IIP-19 task.

Co-Is/Partners: Greg Kopp, Erik Richard, LASP; John Lehman, Nathan Tomlin, NIST

TRL_{in} = 2 TRL_{out} = 5