Ultrafast silicon nanomembrane microbolometer for long-wavelength infrared light detection

Chen Chen¹, Cheng Li¹, Seunghwan Min², Qiushi Guo¹, Zhenyang Xia², Dong Liu², Zhenqiang Ma² and Fengnian Xia¹

¹Department of Electrical Engineering, Yale University, New Haven, Connecticut 06511, USA
²Department of Electrical and Computer Engineering, University of Wisconsin-Madison, Madison, WI, 53706, USA

Schematic Design and SEM image of the microbolometer device

- Diabolo Antenna: high and polarization-independent infrared absorption and ultra-compact pixel area of 6.2 µm
- Ti-Si-Ti Schottky barrier resistor: thermistor material to achieve a high TCR
- Suspended and isolated device: reduced thermal conductance and enhanced thermal isolation

Transport and photoresponse properties of the microbolometer device

- High TCR of 5% (Much improved compared with commercialized VOx or α-Si as thermistor material with a TCR ~2%)
- Measured Photocurrent: $I_{ph} = 323 \text{ nA} (0.8V/4.4 \mu W)$; Extrinsic Responsivity: $73.5 \text{ mA/W}$; NETD: 830mK
- Calculated thermal time constant: $\tau_{th} = R_m \times C_m = 14.6 \mu s$; corresponding $f_{3dB} = 1/2\pi \tau_{th} = 11 \text{ kHz}$
- Consistent with the negligible photoreponse degradation with the modulation frequency up to 10 kHz

Figure of Merit

Figure of Merit (FOM): $FOM = NETD \times \tau_{th} \times A_p$

In comparison with commercialized microbolometer
- The NETD is 10 times larger (830 mK in comparison with 50 mK)
- However, the TTC is 500 times smaller (14.6 µs in comparison with over 10 ms)
- The FOM is at least 20 times improved compared with the reported microbolometers
- The thermal resistance is a trade-off between the TTC and the NETD, it is possible to further increase thermal resistance to achieve low NETD with still much improved TTC