

Semiconductor Bolometers

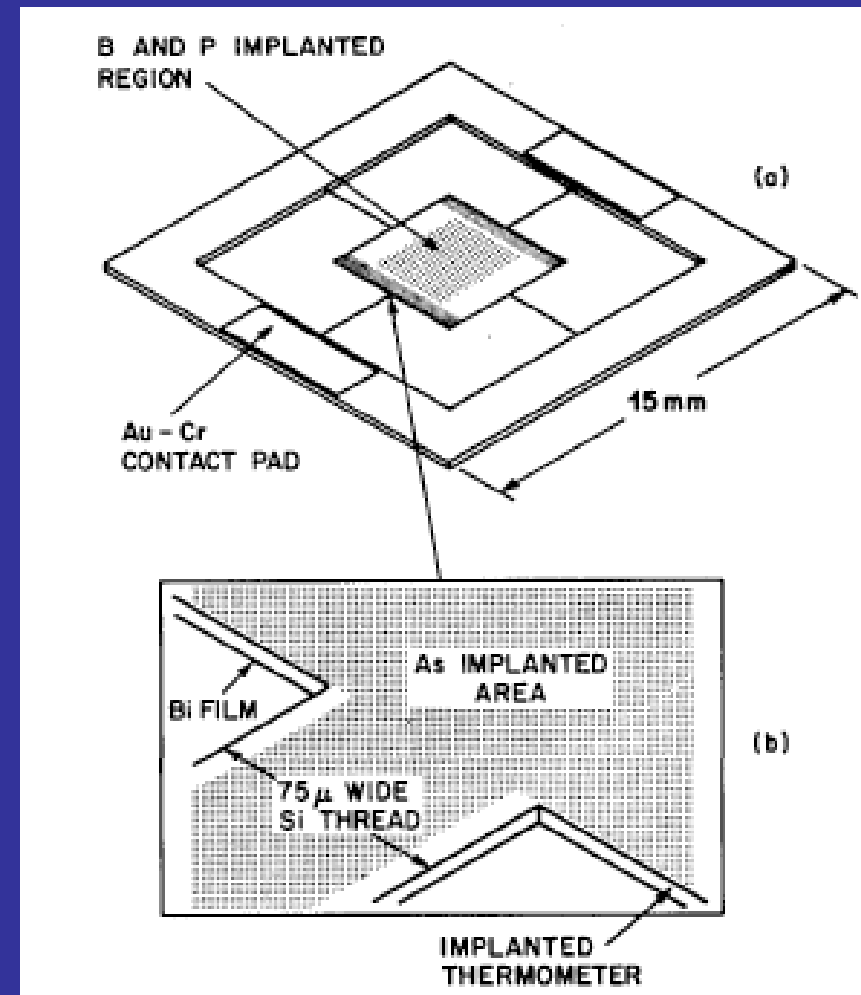
H. Moseley

Aug. 25, 2008

CMB Polarization Workshop

New Fabrication Techniques

- Precision fabrication
- Controlled electrical and thermal properties
 - Predictable response and noise -> Arrays!



Downey, P. M. Appl. Opt. 23, 910 (1984)
CMB Polarization Workshop

History

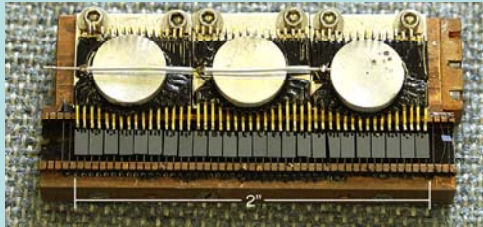
- 1 pixel, handmade – *mid 1980's*

COBE

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

- 24 pixels, handmade – *late 1980's*

KAO



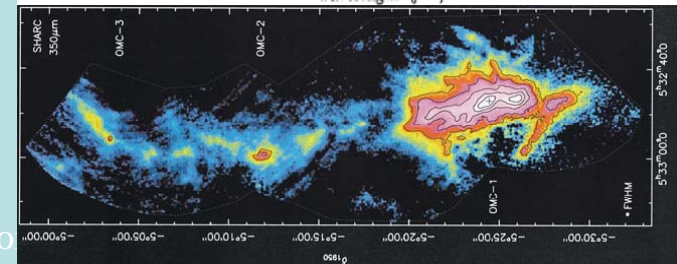
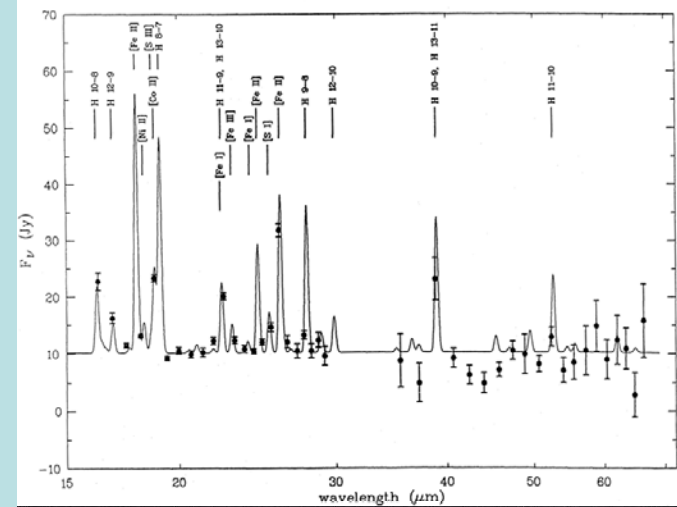
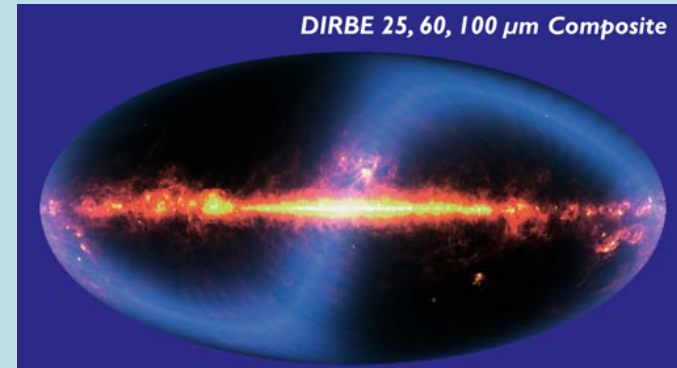
- 24 pixels, micromachined – *early 1990's*

KAO/CSO



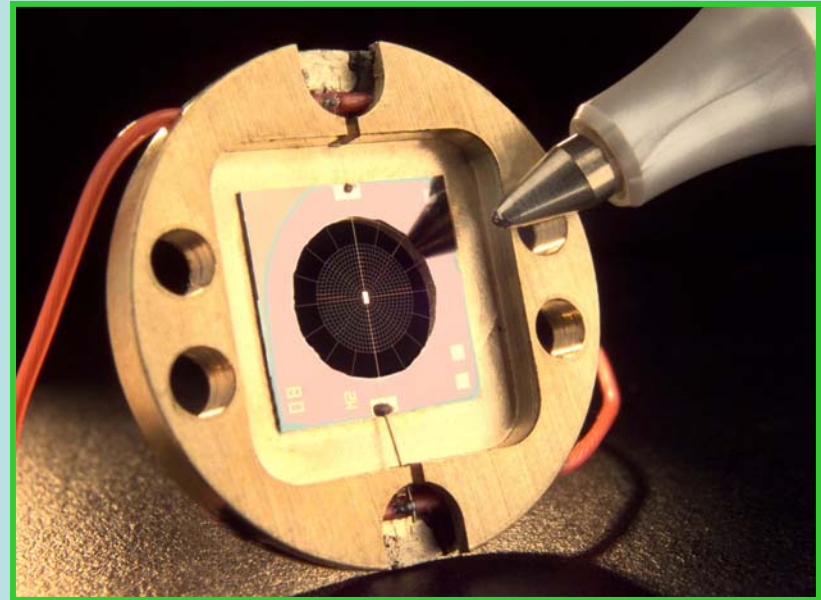
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Spider Web Bolometer

- SiN micromesh detectors with NTD Ge were developed by UCB and Caltech, very successfully deployed



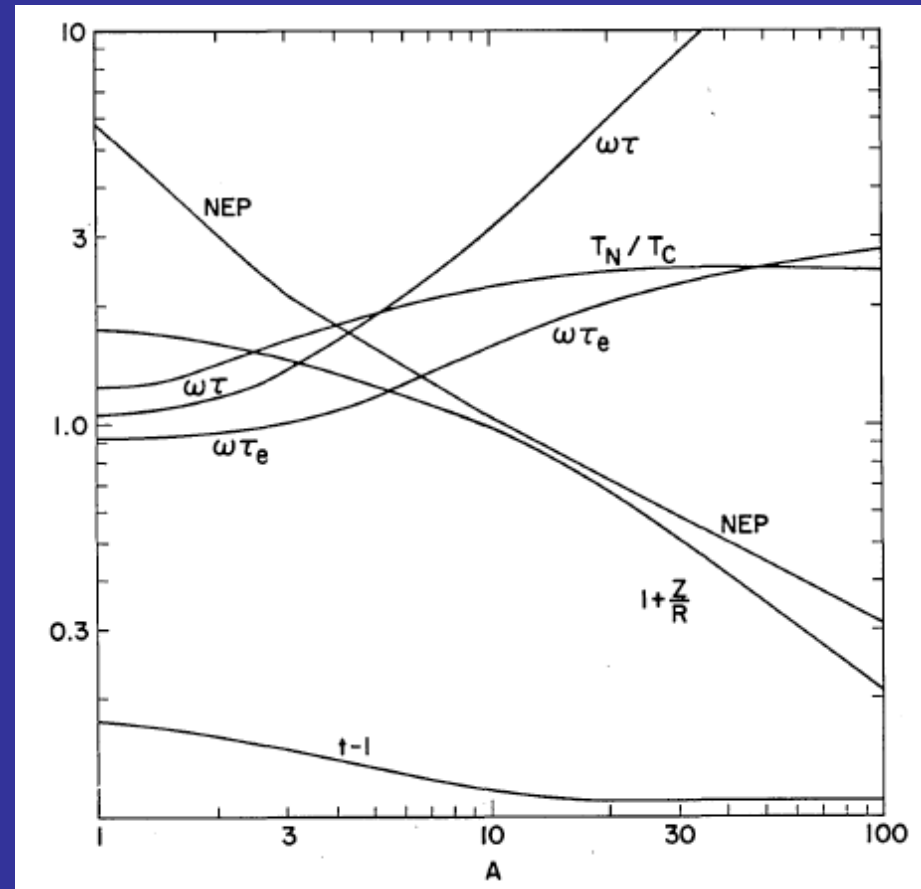
Advances in Theory

- Treats nonequilibrium effects of noise
- Shows benefits of high temperature sensitivity
 - NEP $\sim 1/\text{Sqrt}[A]$ for zero background
- Focuses on fundamental limits

Mather, J. C. Appl. Opt.
23, 584 (1984)

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$$R(T) = C (T/T_0)^A$$

Semiconductor Bolometers Can Meet Sensitivity Requirements

QuickTime™ and a decompressor are needed to see this picture.

=

QuickTime™ and a decompressor are needed to see this picture.

Photon Noise

Phonon Fluctuations

What is the Required Operating Temperature?

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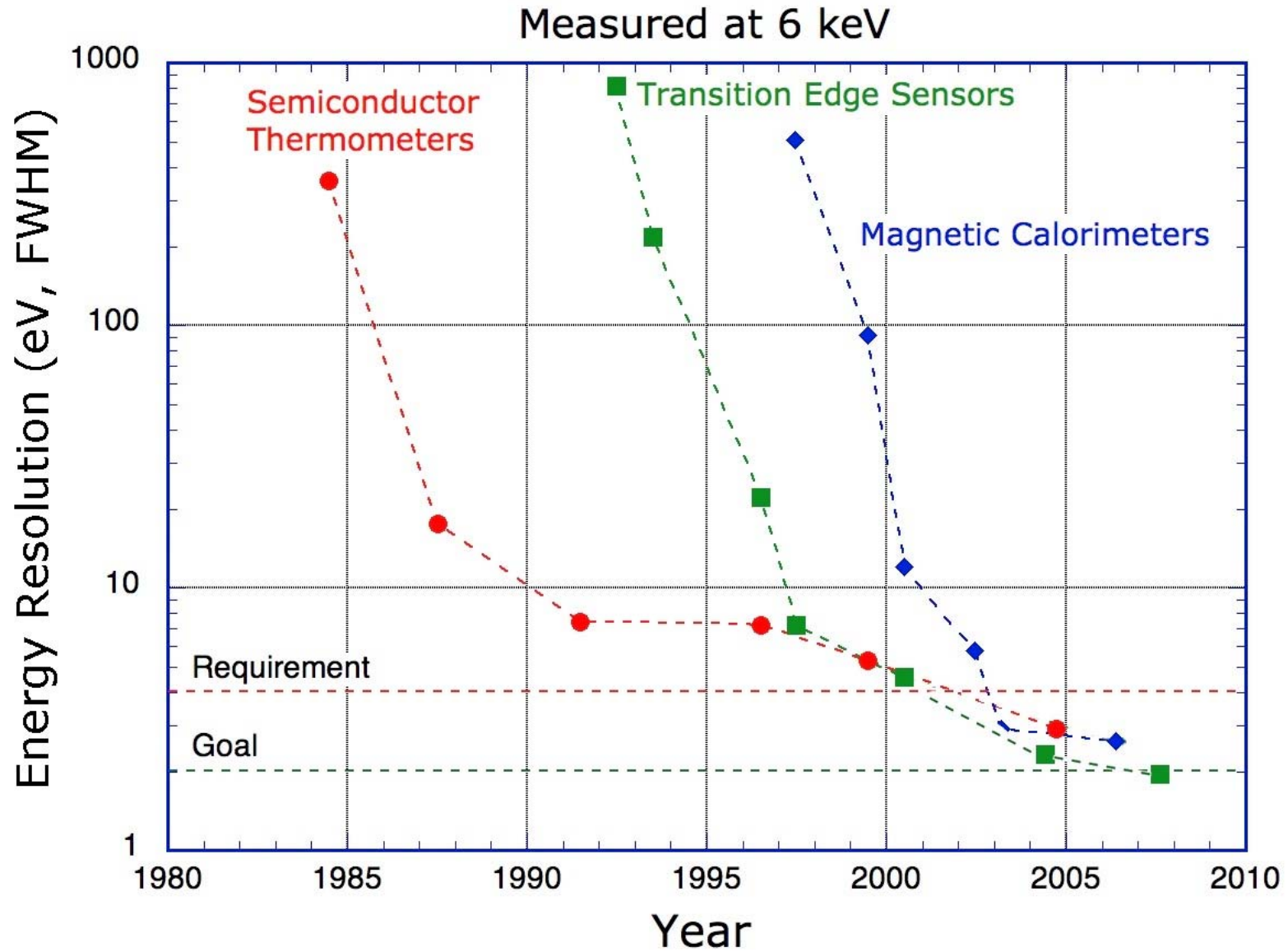
with

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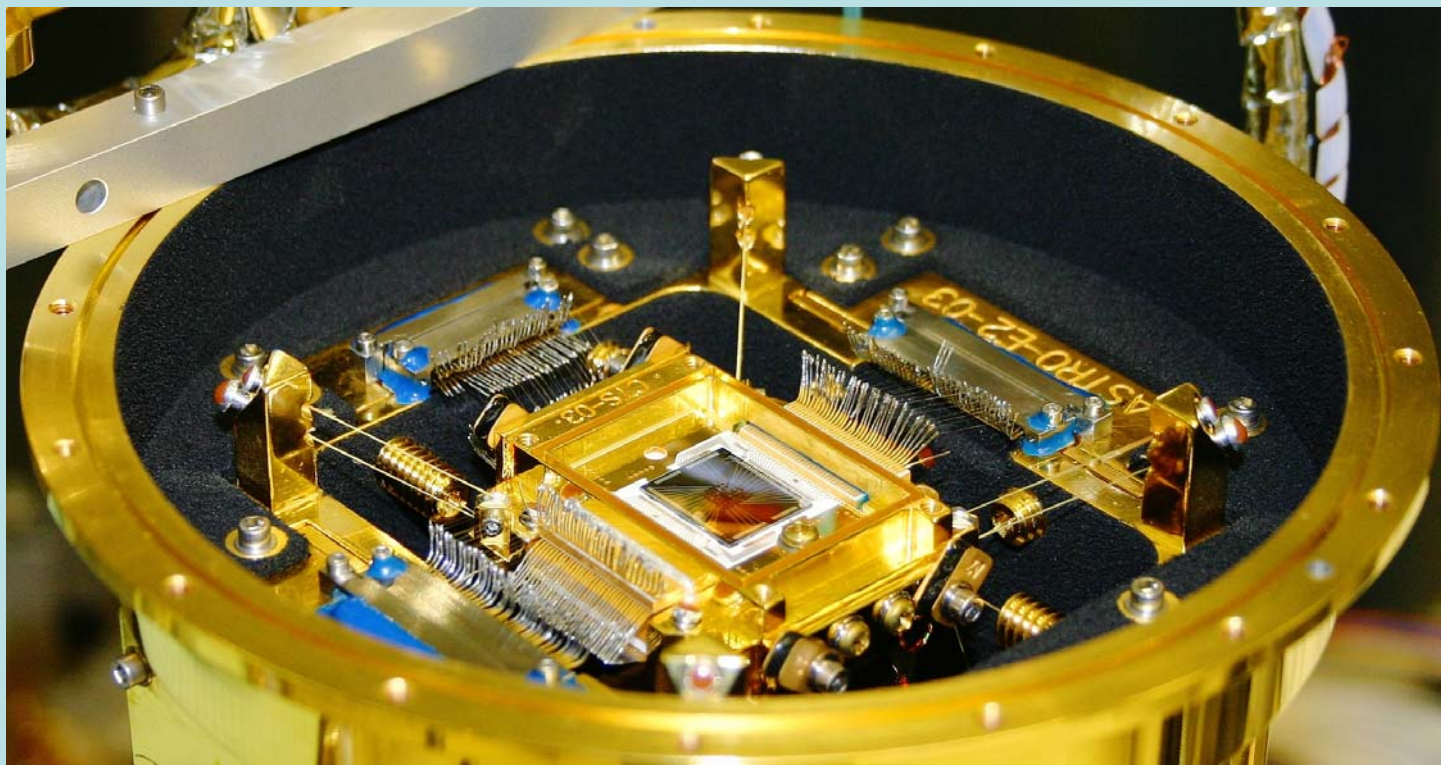
so

QuickTime™ and a decompressor are needed to see this picture.



XRS II for Astro-E2

Successfully Operated in Space
Cryostat Failed



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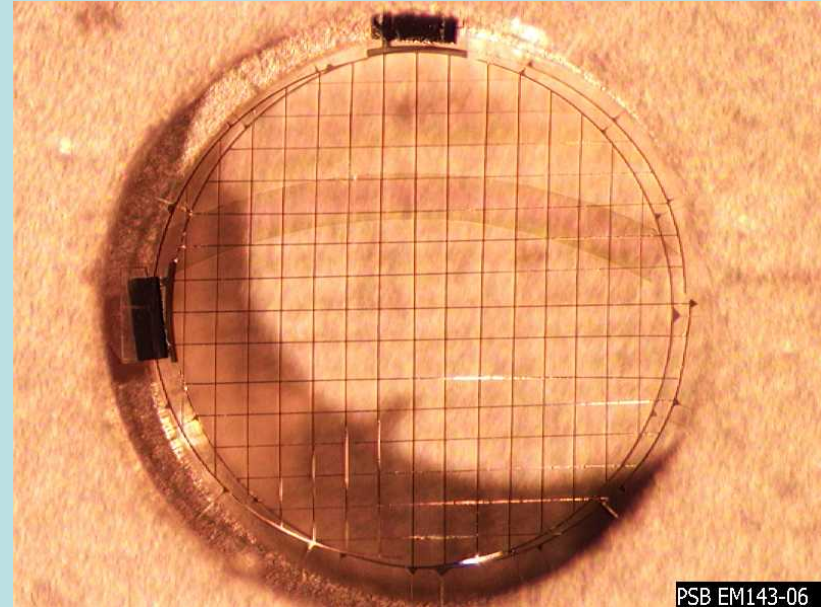
CMB Applications

- Long and Successful History
 - COBE - FIRAS
 - Boomerang, Maxima
 - ACBAR (South Pole)
 - BICEP
 - Planck (coming soon!)
 - EBEX (coming soon)

Polarization Sensitive Bolometers - Semiconductor-Friendly

Polarization-Selective Bolometers for BICEP

- Arrays of 200 detectors
- Hand-assembled semi-conducting detectors
- Absorber-coupled architecture



PSB EM143-06

**The First Pair of Polarization-
Selective Bolometers**

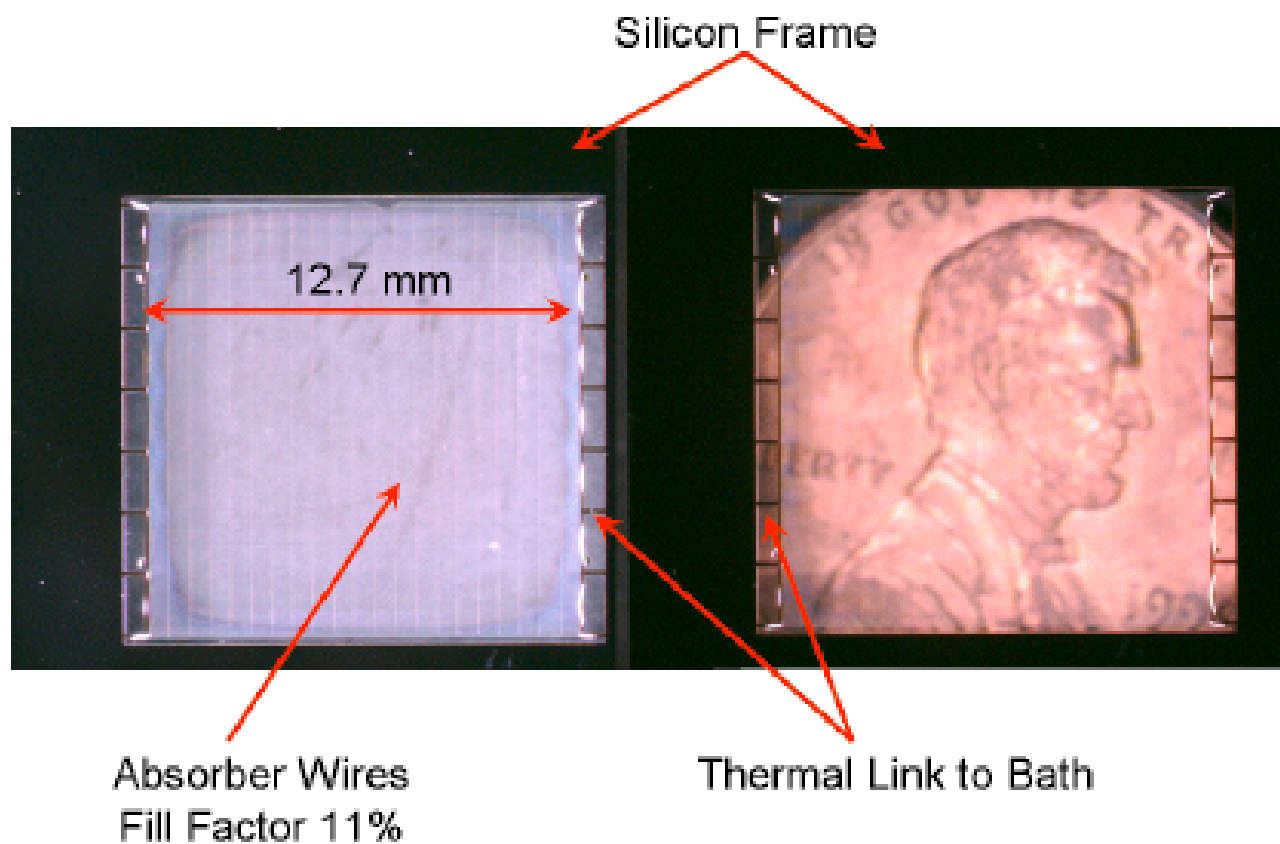
Advantages

- Mature technology
- Predictable performance
 - Can “dial in” desired characteristics
 - Sensitivity can be achieved at low temps
 - Caveat - thermal conductance still empirically determined

Disadvantages

- Complex thermal interface to JFET amplifiers
 - No convenient low temp mux (exception - Saclay MOSFET mux)
- Interface to microstrip not mature
- Low temperature coefficient lead to slow response

ASP Detectors



Kogut et al.

Status

- Some designs high TRL
 - COBE, Planck
- Microstrip coupled - Low TRL
- Little effort in development because of multiplexer problem
 - Kogut's ASP is an exception
 - If mux were available, would be widely used
 - HEMTs can't be used, because $T_{\text{noise}} \gg T_{\text{det}}$