Cantilevered X-ray Absorbers for Close-Packed TES Detector Arrays

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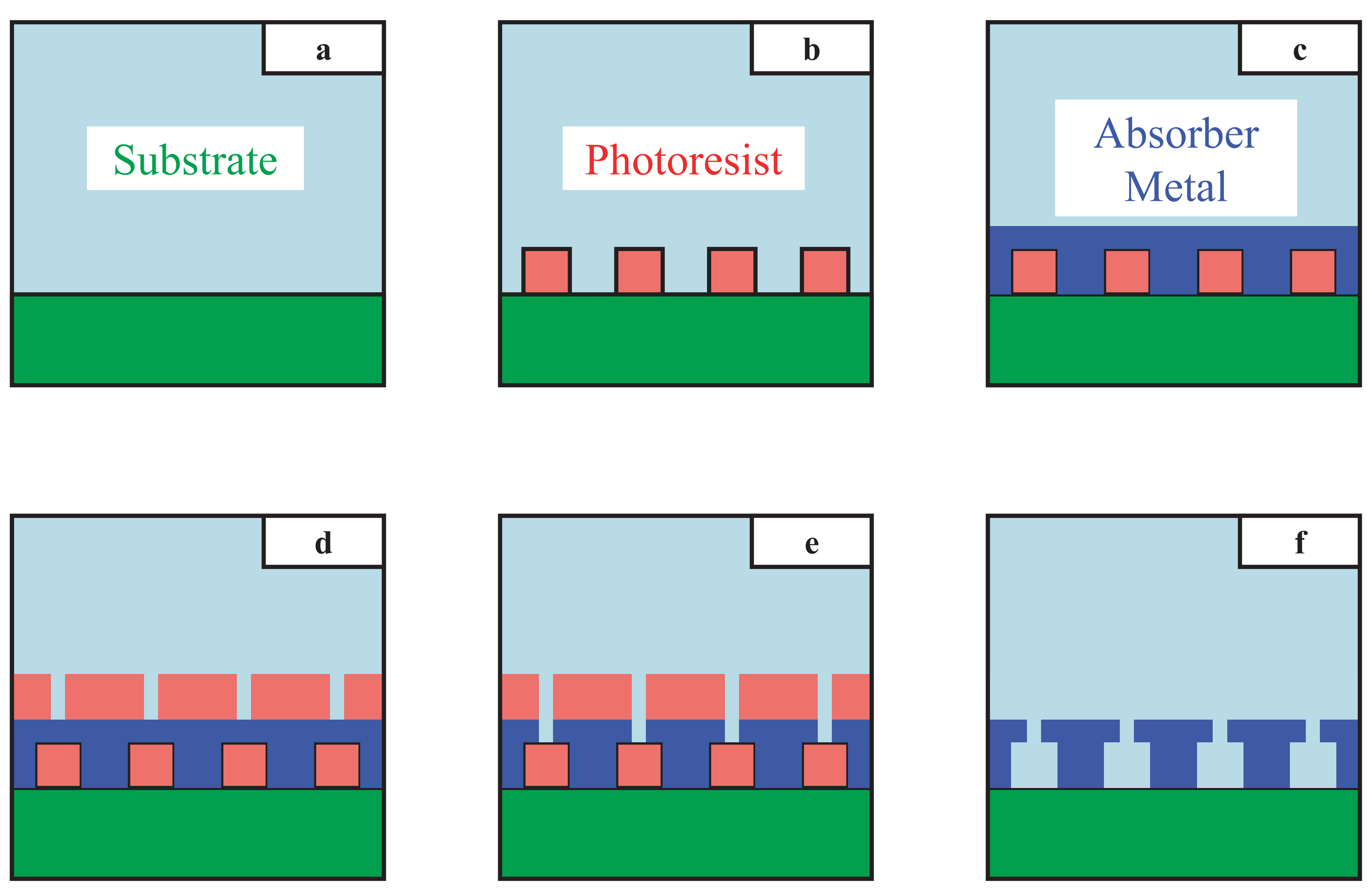
Introduction:

An integral component of an x-ray calorimeter is an x-ray absorber. In order to achieve optimal calorimeter performance, the absorber must possess low heat capacity, high thermal conductance, and high quantum efficiency. These three parameters can be tuned by judicious selection of absorber materials and design.

In this study, we have developed a generic methodology for fabricating 8x8 cantilevered absorber arrays that can be integrated into our Mo/Au transition edge sensors and is compatible with physical vapor deposition and electrochemical deposition. Thus, this methodology allows us to employ a wide variety of absorber materials so that we may freely probe parameter space, and, ultimately, optimize detector performance.

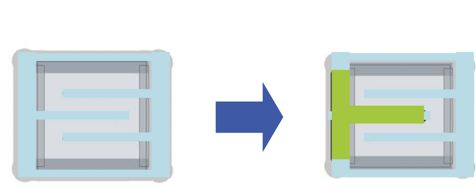
Here, we examine the morphology and mechanical robustness of evaporated Bi/Au, Bi/Cu, and electroplated Au cantilevered absorbers and discuss their utility in terms of calorimeter performance.

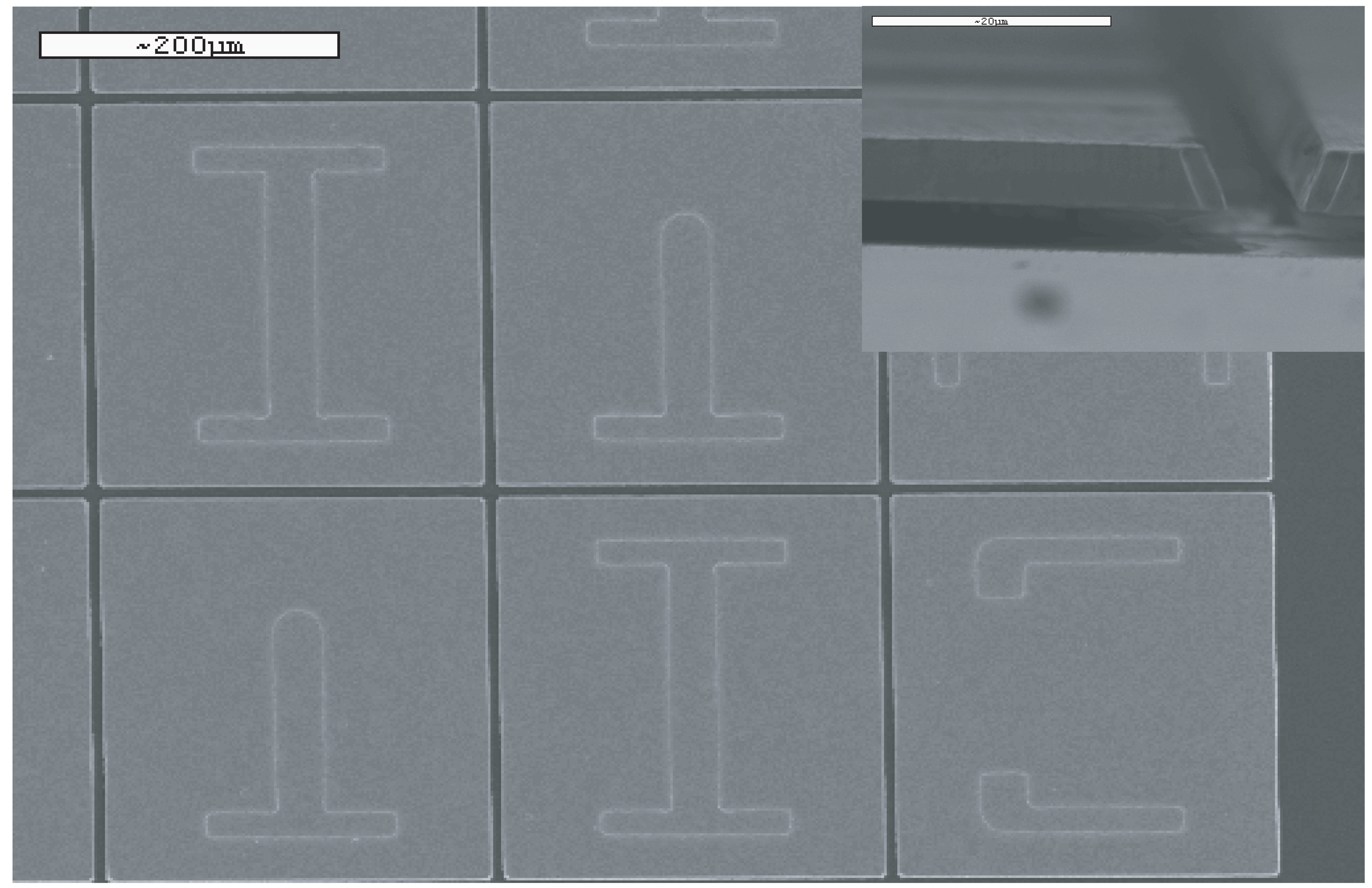
Absorber Fabrication Methodology:



a. Start with TES and Au bars grown atop Si_3N_4 coated Si wafer. **b.** Pattern absorber stem with photoresist. **c.** Deposit absorber metal. **d.** Pattern absorber pixels with photoresist. **e.** Ion mill to separate pixels. **f.** Dissolve photoresist.

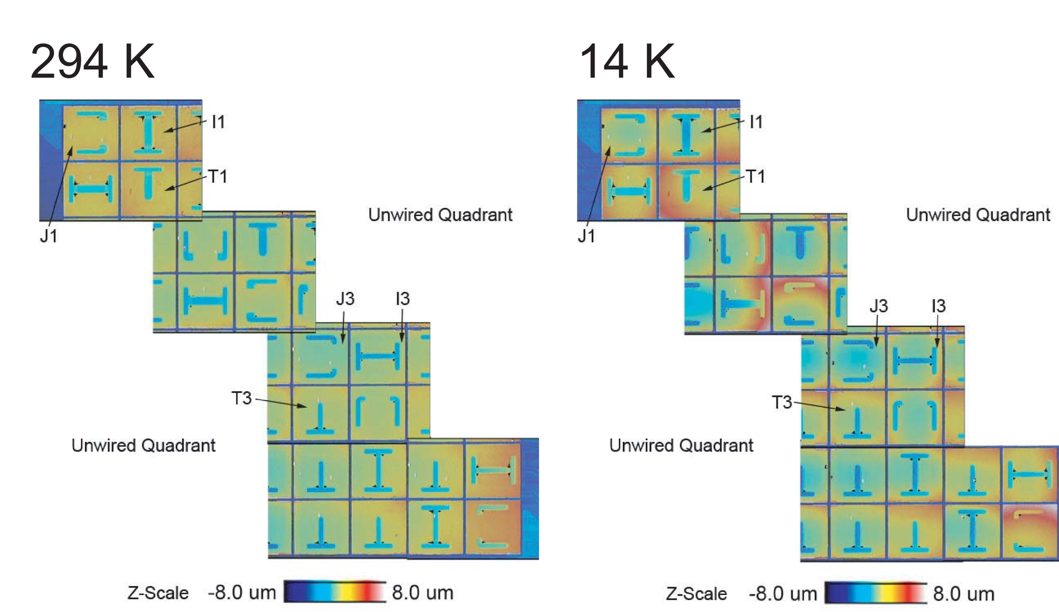
Our absorber stems, highlighted in green, were grown atop Au "landing pads", in blue, and cantilevered over the TES, in grey, so as to circumvent problems associated with interface chemistry between the absorber and TES.



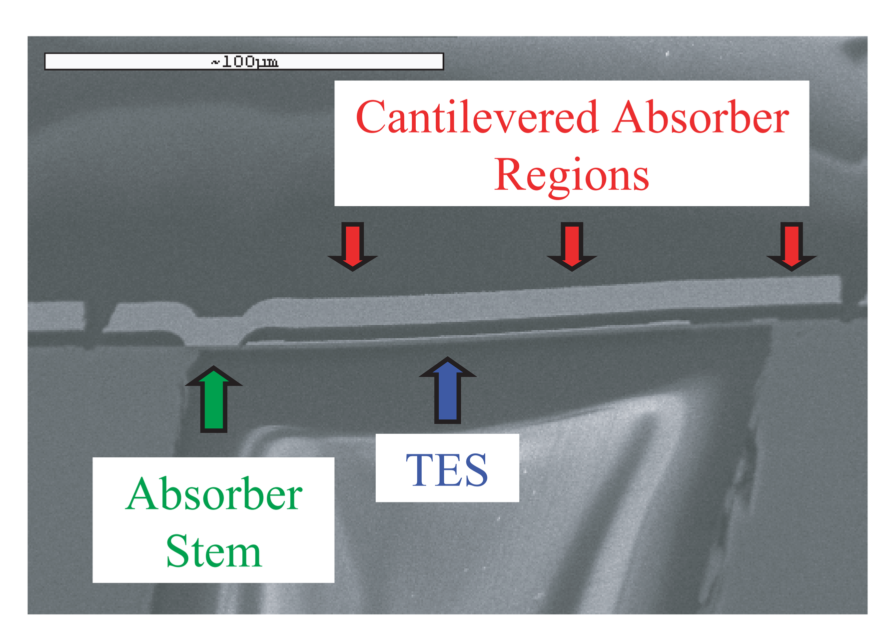


We fabricated absorbers possessing different stem designs, as illustrated in this SEM micrograph, in order to study the effect of different thermal and electronic pathways between the absorber and TES.

Different stem designs will also allow us to compare detector performance to different absorber strain. Confocal microscope images illustrate that symmetric (H's and J's) stems have a tendency of being less strained than asymmetric (T's) stems at sites 1 and 3.

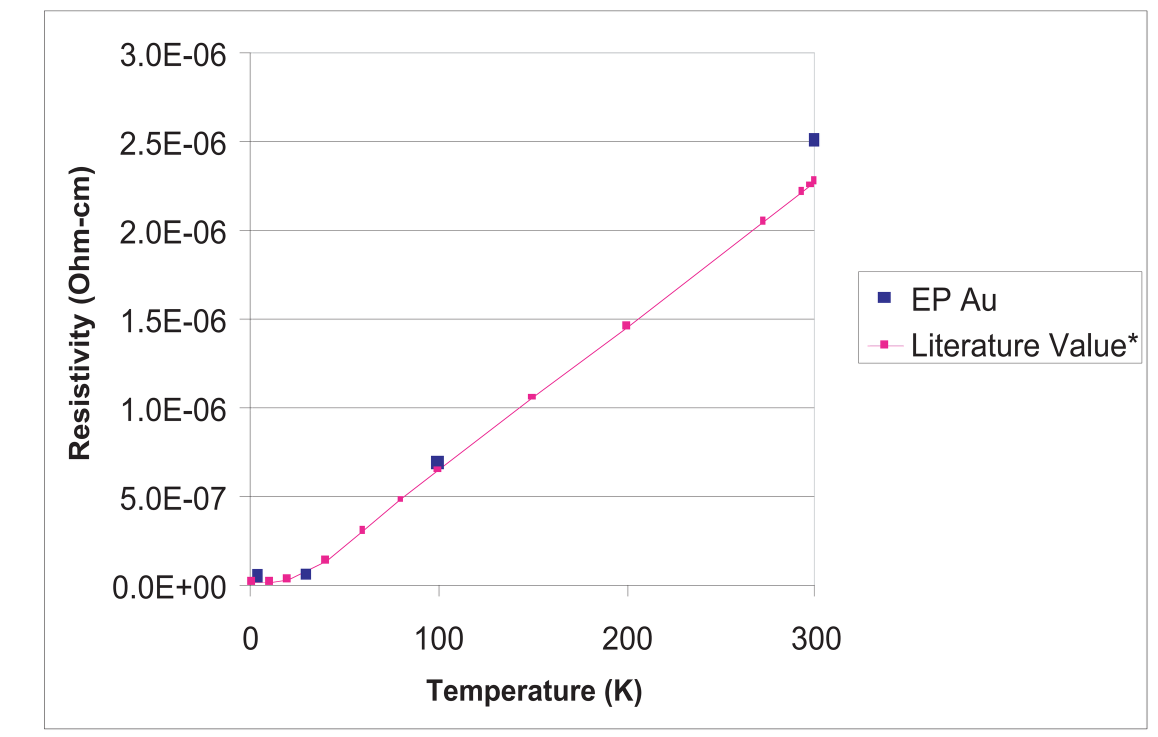


We have been able to fabricate mechanically robust absorber arrays possessing a filling fraction of 95-97%. Cross section SEM images show the absence of cantilevered-absorber bending, which insures that our absorber will not short out the TES.



Electroplated Absorbers:

Initial analysis suggests that, when integrated into our detectors, all- Au electroplated absorbers perform much better than evaporated Bi/Au or Bi/Cu absorbers.

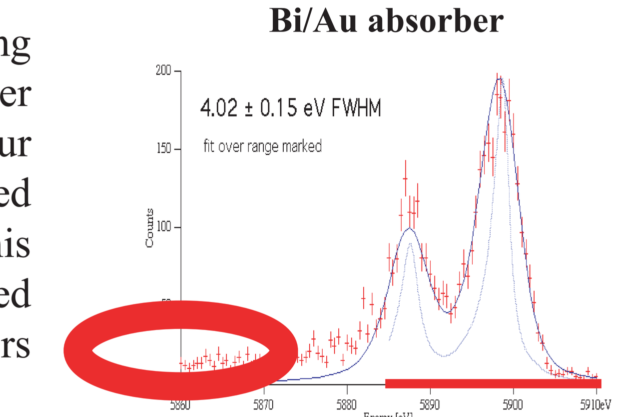


EP Au: t = 6.5 microns, RRR = 46.85; 1 mA/cm^2; Bath temperature = 50 C

Electroplated Au possesses a very low resistivity as compared to evaporated metals (Au, Bi, Cu), and, consequently, should possess a very high thermal conductivity.

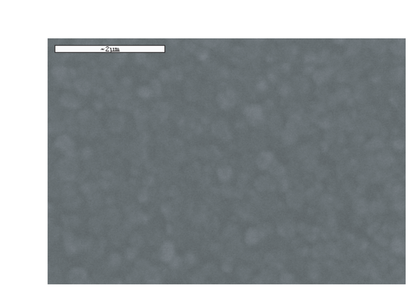
We observe excessive broadening of the energy curve at the lower edge of the spectrum if our detectors possess evaporated Bi/Au absorbers; however, this spurious effect is not observed when electroplated Au absorbers are used.

Bi/Au absorber

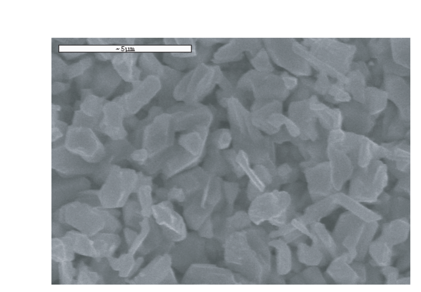


Future Work:

- Optimizing absorber stem design.
- Further characterization of detectors possessing EP Au absorbers.
- Employing EP Bi absorbers in our detectors**.



Evaporated Bi



Electroplated Bi

* Lide, D. R. "Handbook of Chemistry and Physics 75th Ed." New York: CRC Press, 1996-1997: 11-41.

** T. Arakawa, et al., "Fabrication of multi-pixel TES microcalorimeters with an electrodeposited Sn absorber and Bi absorber," Nucl. Inst. and Meth. in Phys. Res. A **520**, 456 (2004).

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