WIRE FUSING

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PREECE EQN

- 1884: Preece* considered balancing heat generation from I^2R with heat loss as πhdl for a wire element of length dl with heat loss per unit area (from radiation) of h.

$$I_f = \frac{\pi}{2}(\sigma h)^{1/2} d^{3/2}$$

I_f = fuse current
σ = electrical conductivity
d = diameter of wire

- Complemented by the other limit, where heat loss is not relevant (e.g. instantaneous pulse without radiative losses).

$$I_b = d^2 \frac{\pi}{4} \sqrt{\frac{\int \rho C_p dt}{\int dt/\sigma}}$$

I_b = burst (melt/vaporisation) current
ρ = density of material
C_p = specific heat (incl. latent heat)

- Preece's argument relied on data to determine fusing currents for some fixed length, and so this argument does not hold for short bonds - should work for long enough wires where heat loss dominates.
- Assumes that the wire is in free air - so that's also not the case if we pot bonds or bond heels.

*Preece, Royal Soc. Lon. **36**, 464 (1884); ibid **43** 280 (1887)

MODIFIED PREECE EQN

- Can take Preece and replace the constant of proportionality with some different value to account for the situation (MIL-SPEC uses epoxy packaging corrections; so corrections would be required for potted bonds or potted heels).
  - Does not apply to wires longer than 1mm
  - Does not have a material dependence
  - … not very useful.

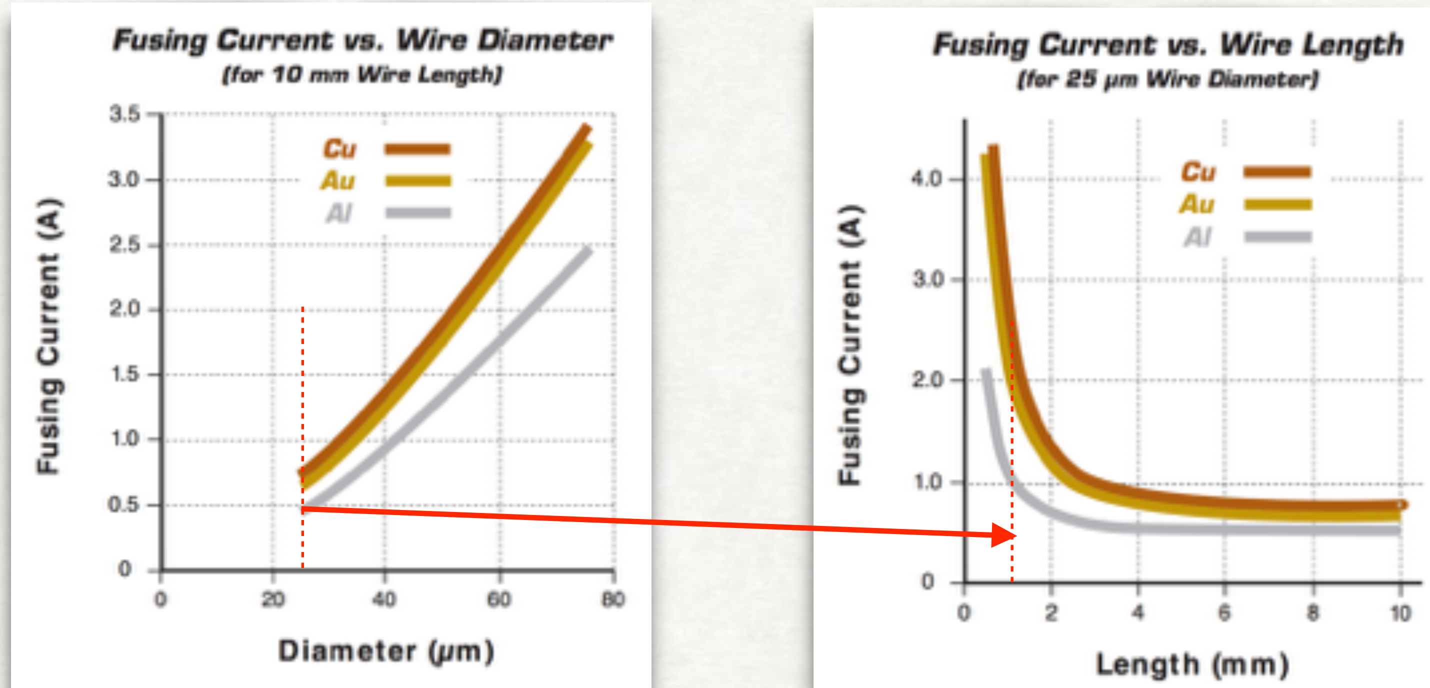
- Other models exist*; again these have assumptions; Stephan dug out the Power Systems Design article in his e-mails; Chen et al. go into more details, but these are still linear modes.

- Ultimately model based estimation may not be a good way to understand fuse and burst current limits for our use case.

*K. Chen et al., Prog Elec. Res. **31**, 199-214 (2013); J. Shah, Power Systems Design Jul/Aug 2012

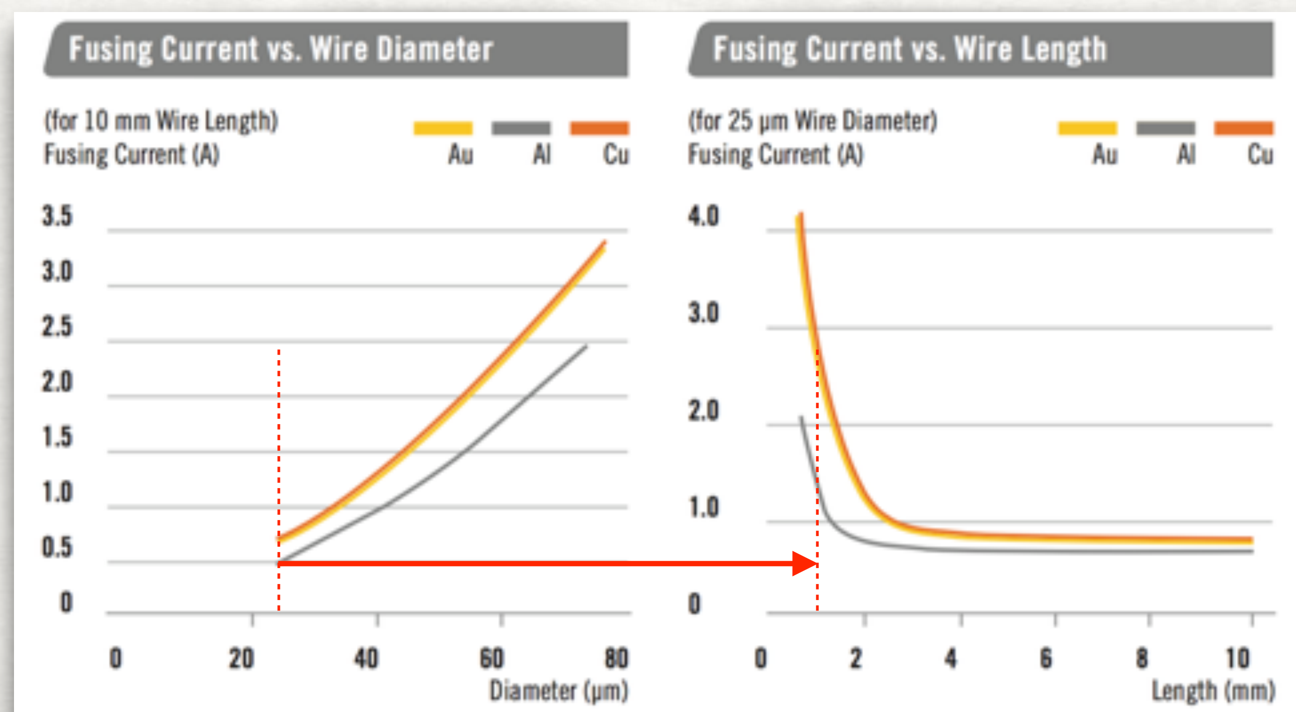
SUPPLIER SPECS

- K&S specs: ~400 mA for a 25µm bond (1mm length).



WARNIG: Slight incompatibility (factor of 2) between LHS and RHS plots…

- Heraeus specs: bigger discrepancy apparent



WARNIG: Slight incompatibility (factor of 2) between LHS and RHS plots…

I don’t trust the integrity of these results given that I can’t understand the mis-match. *Are they just Marketing plots?*

WIRE CURRENT LIMITS ASSUMED

- Strips:
  - Ashley assumes an 800mA fuse current (including a naively assumed [i.e. guessed] factor of 2 for TID bump).

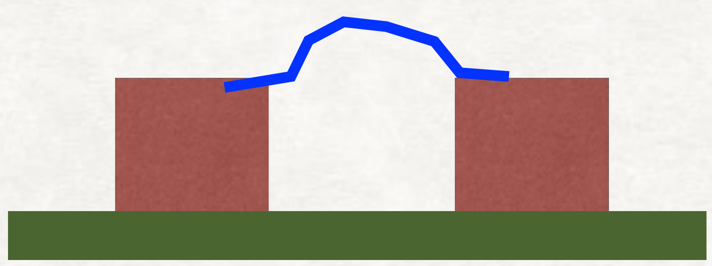
- Wire: 25μm x 250μm ribbon has a fuse current of ~3.5A for a 2mm length according to Accelonix.
  - 4 bonds “should” cover 9A (modulo reduction in fuse current from increased length with some overhead.

WHAT ARE OUR FUSE CURRENTS REALLY?

- There is a lot of physics that goes into fuse currents - and it is clear that the literature has differences of opinion, and the manufacturers provide inconsistent results in their catalogues.

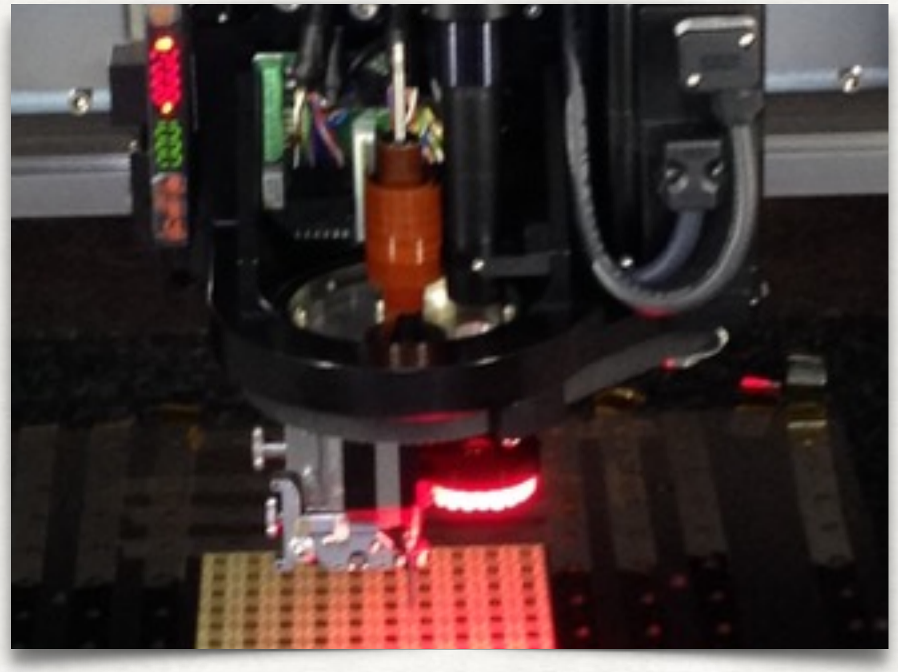
- I think this merits a quick bench test to understand our safety factors.

- Setting up a simple jig to bond out and fuse wire on to see how accurate plots are from Heraeus and K&S.



- Can re-work jig for different lengths (and ribbon tests).

WHAT DOES A DEEP ACCESS HEAD LOOK LIKE?



- The QM BJ820…
- DA head is setup in this picture for 25μm Al wire.
- Quickly reconfigurable to ribbon:
  - Requires a spool change, ribbon guide change, tool change and a modification to the wire feed loop gap.
  - Something that is straightforward to do.
  - Can also test ribbon fuse current if we buy ribbon and bond tools.