Experimental Techniques For SEE Tests at Low Temperatures

By

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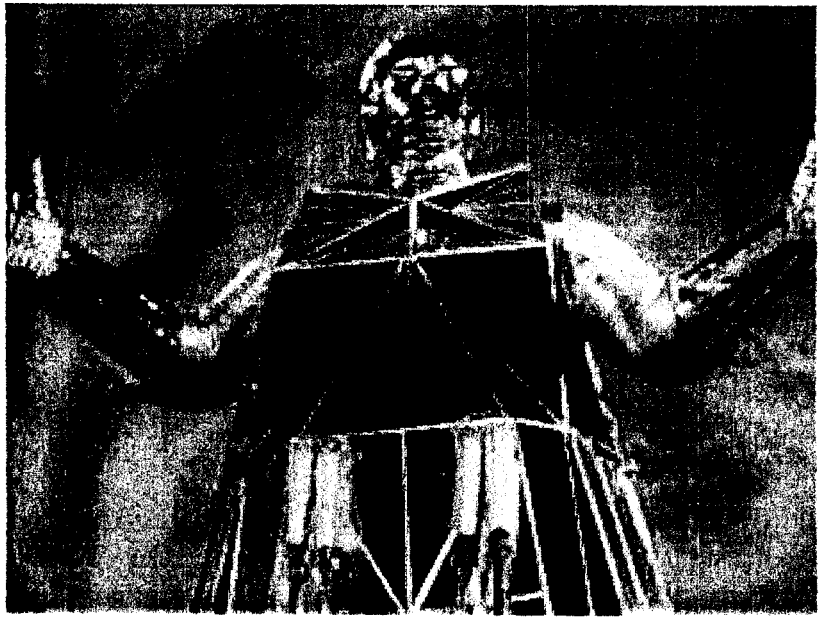
Road Map

- Motivation
- SEE Approaches
- Solution(s)

  Conclusion
- SEE Results



"It's my job to freeze you…"

Motivation

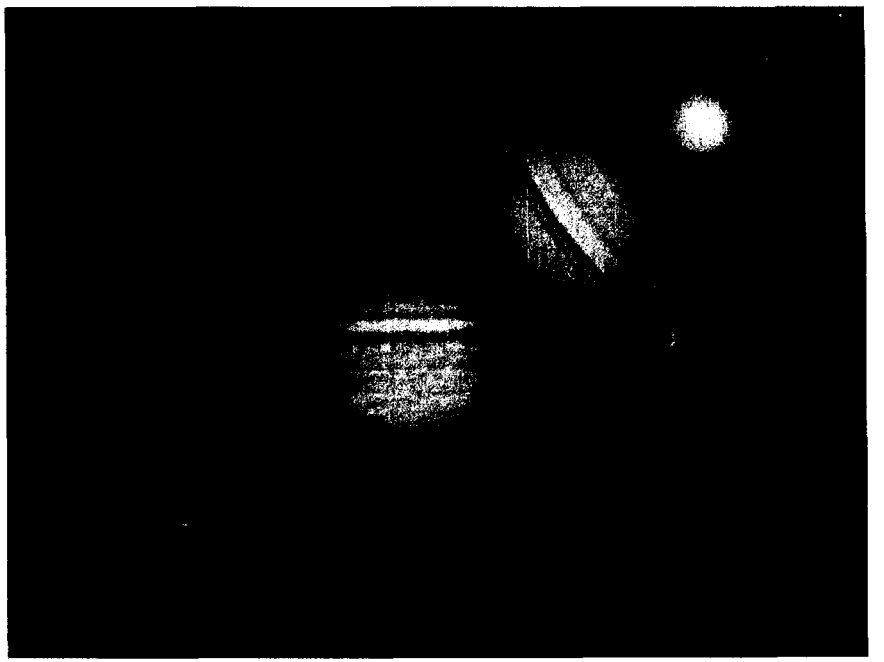
- Space Missions:

  Planets

  < -180 to > 400°C

  Satellites

  < -200 to > 400°C



Motivation

- Space Missions:

  Comets (Stardust)

  < -200 to > 400°C

  Up to Our Asteroids

  < -2000 to > 400°C

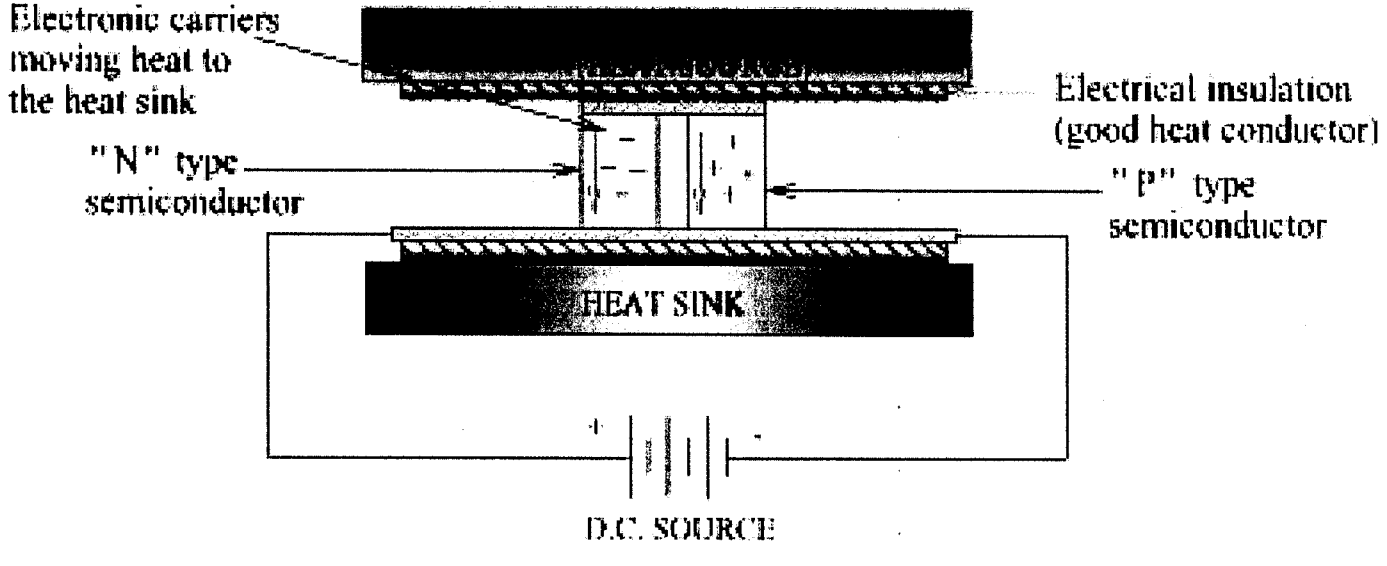
SEE Approaches:

- Various Technologies:
  - Solid State
    - TE Coolers
  - Capillary Action
    - Heat Pipes
  - Conduction Heat Transfer
    - Coldfinger

Mars (-100 to 0°C)

Approaches: Solid State

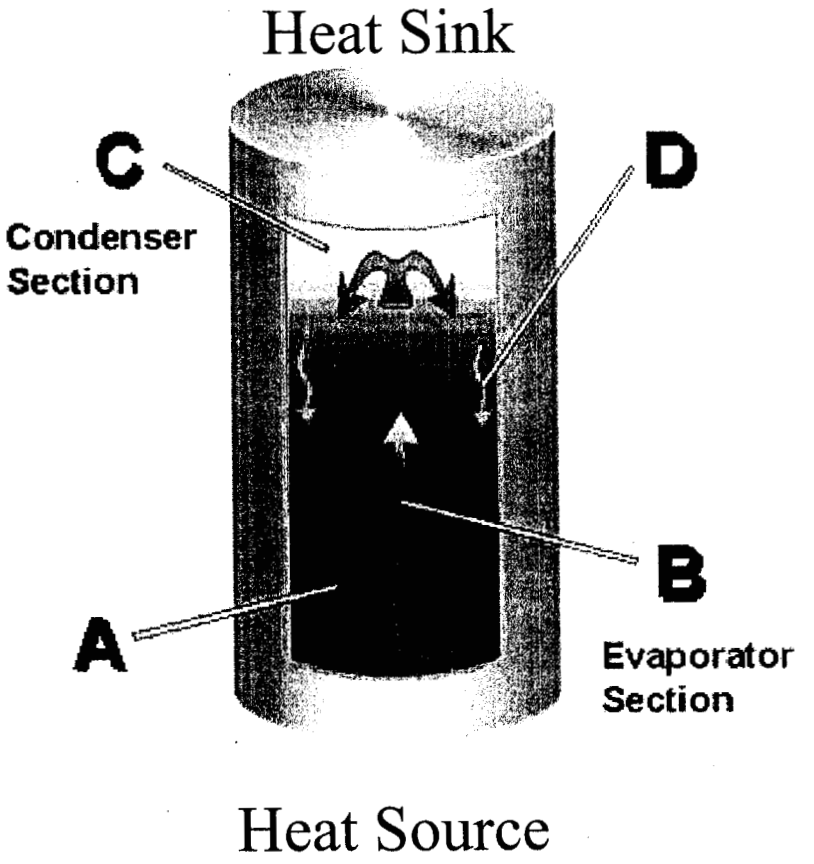
- Thermoelectric Coolers



- Range: ~ 90 to 10°C

Approaches: Capillary Action

- Heat Pipes:
  Compressible fluid
  Wick
- Range:
  Working fluid
  -200 to +2000°C



Approaches: Capillary Action

- Cryotiger

PT-30 gas

~30 watts

at 145K

- Drawback

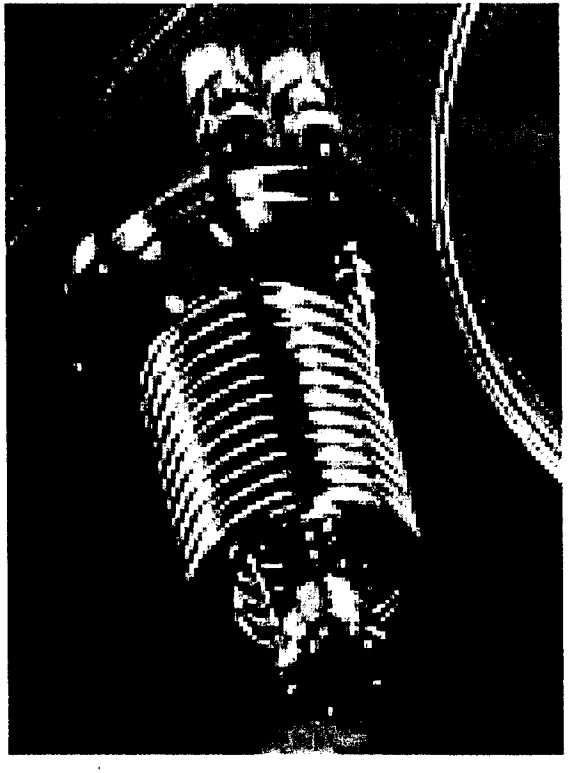
Mat. Safety Data Sheet

Approaches: Capillary Action

- Coldend:

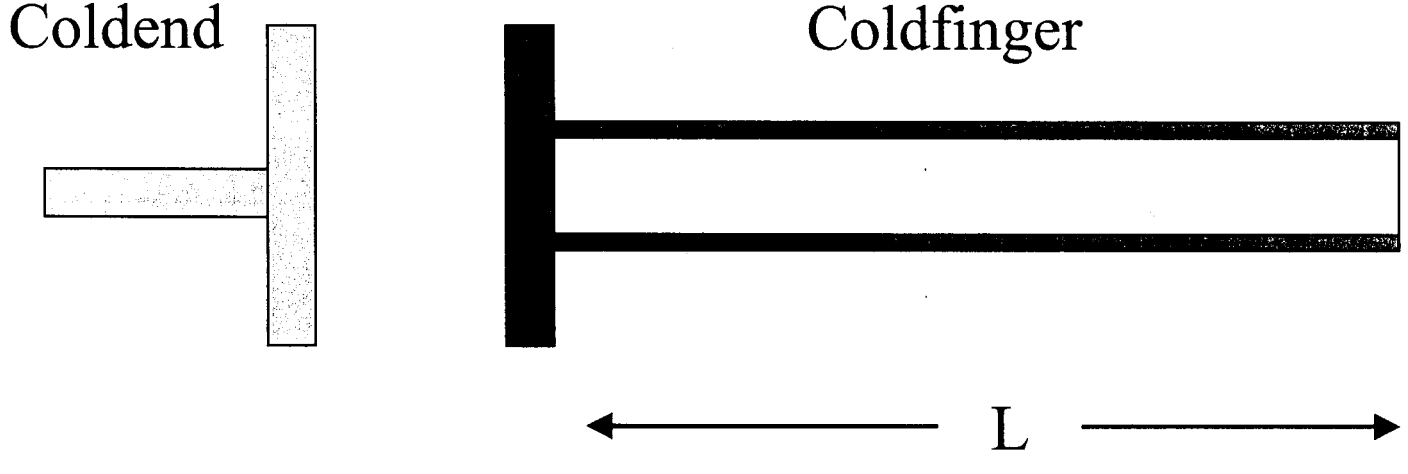
  Nickel Platted

  high performance coldend



Approaches: Conduction Heat Transfer

- Coldfinger



Approaches: Conduction Heat Transfer

- Design Coldfinger Characteristics:
  high Thermal diffusivity

$$\alpha = \frac{k}{\rho c}$$

$\propto$ k (Thermal conductivity, rapid energy transfer)

$\propto$ 1/ρc (low Heat Capacity, less energy absorbed)

Approaches: Conduction Heat Transfer

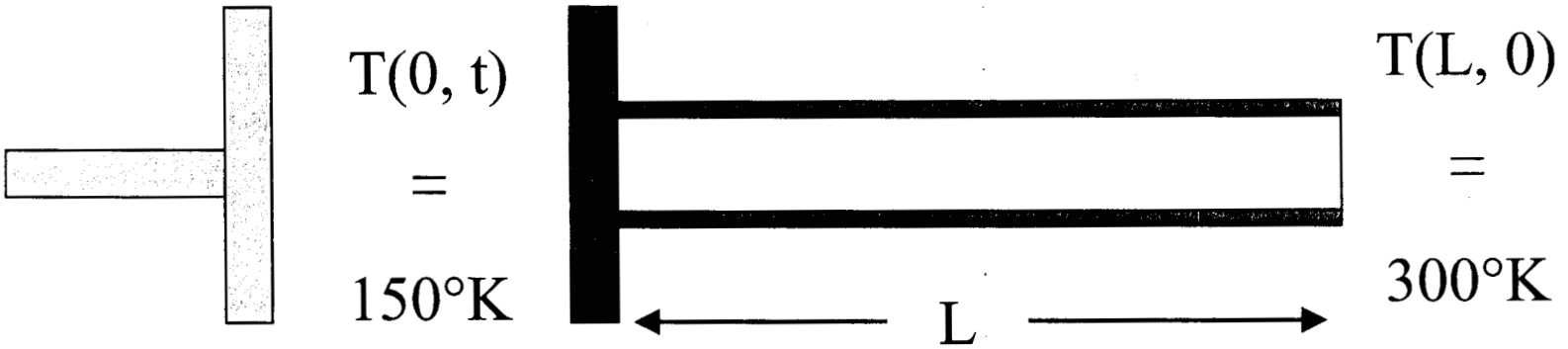
- Options:

  Al, Au, Ag, Ni, Cu, & others (& alloys)
- Constraints:
  1. Easy of machining & welding!
  2. Weight
  3. Rigid enough for load baring
  4. Cost

Approaches: Conduction Heat Transfer

- Temperature Distribution T(x, t) = ?

  B.C.



Approaches: Conduction Heat Transfer

- Analytical Solution:

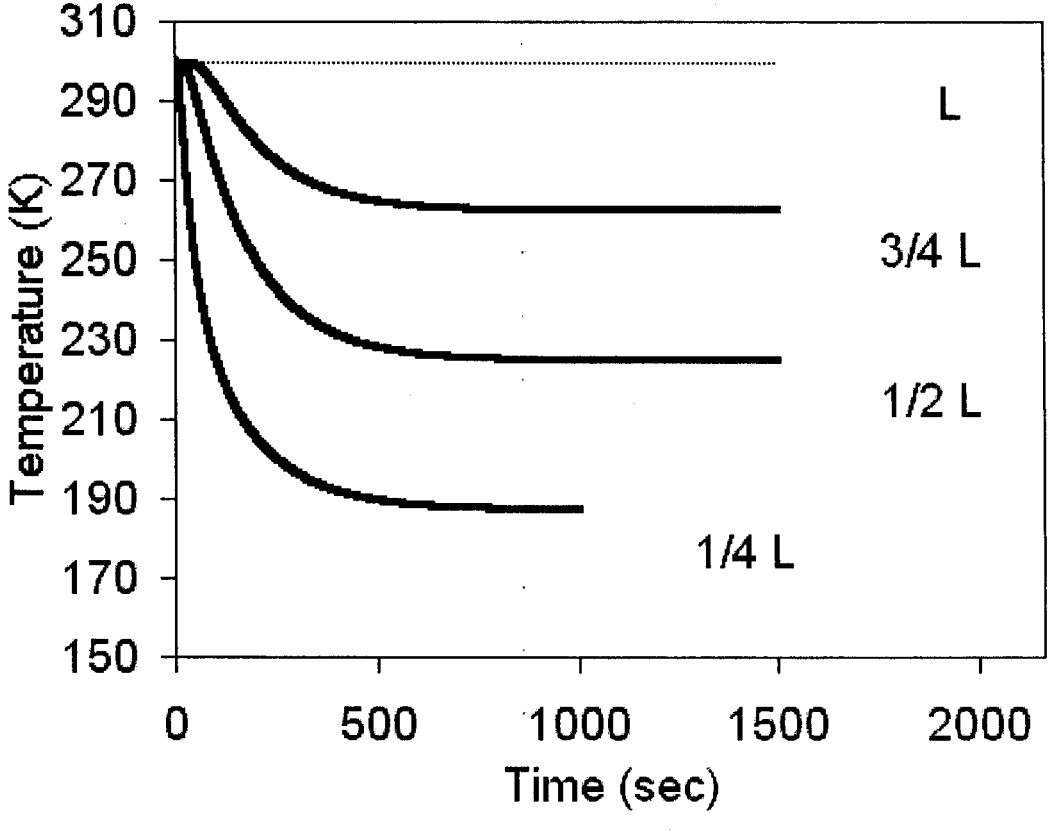
$$T(x,t) = 150 + 150\frac{x}{L} + \frac{300}{\pi}\sum_{n=1}^{\infty}\frac{1}{n}\sin\frac{n\pi x}{L}\exp\left(-\frac{\alpha}{L^2}n^2\pi^2 t\right)$$

Approaches: Conduction Heat Transfer

- Analytical Solution:

$L = 4$ inches

$\tau = 35.6$ min.

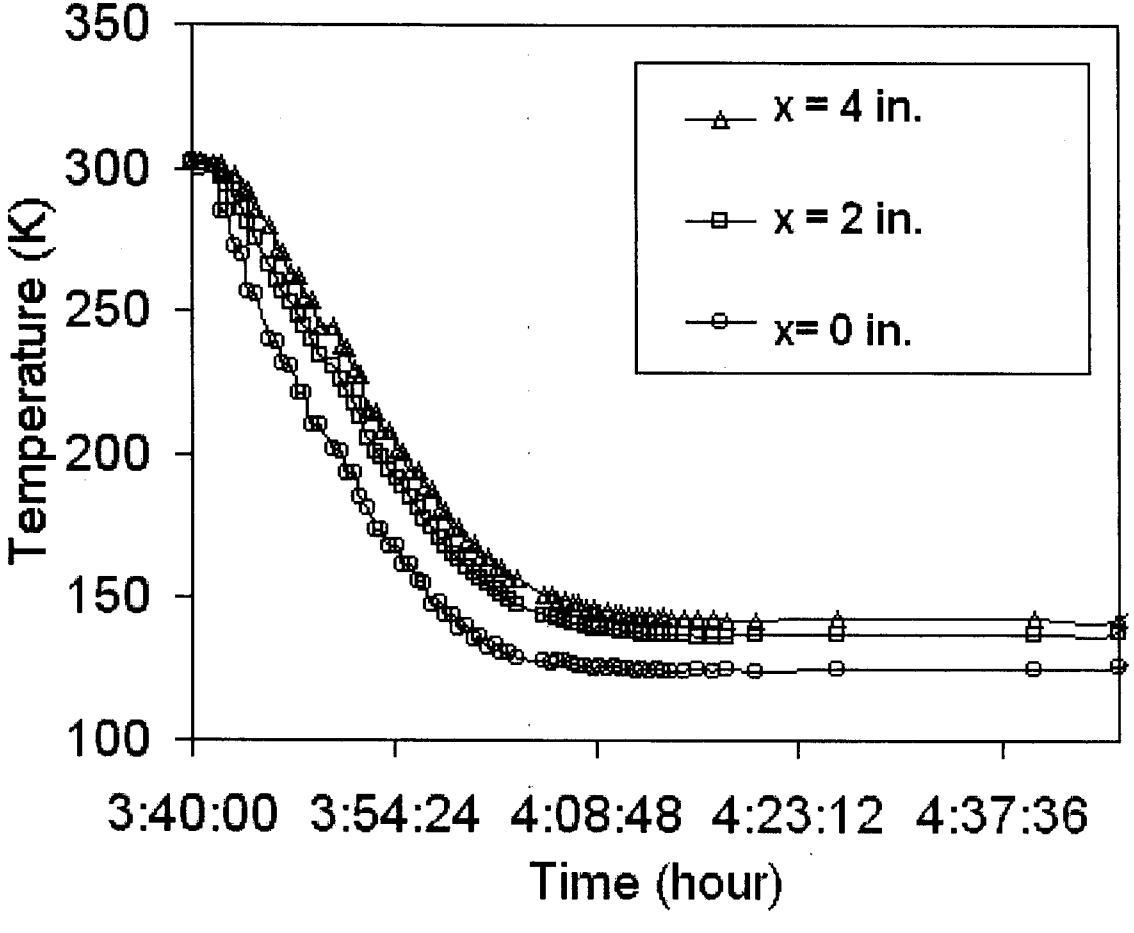


Approaches: Conduction Heat Transfer

- Experimental result:

L = 4 inches

$\tau \sim 36$ min.



Solution(s)/ Conclusions

- Coldend to DUT

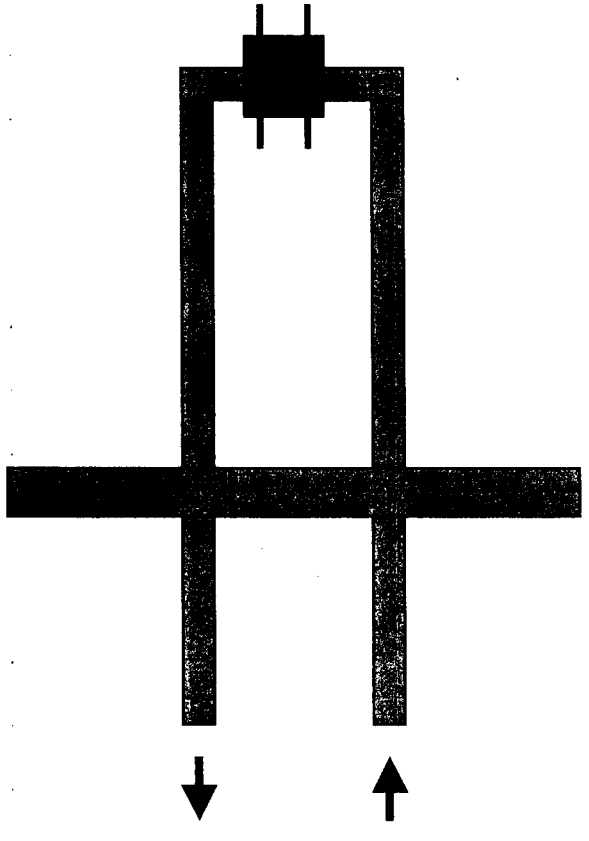
  Heat Pipes

- Extend Coldend to DUT

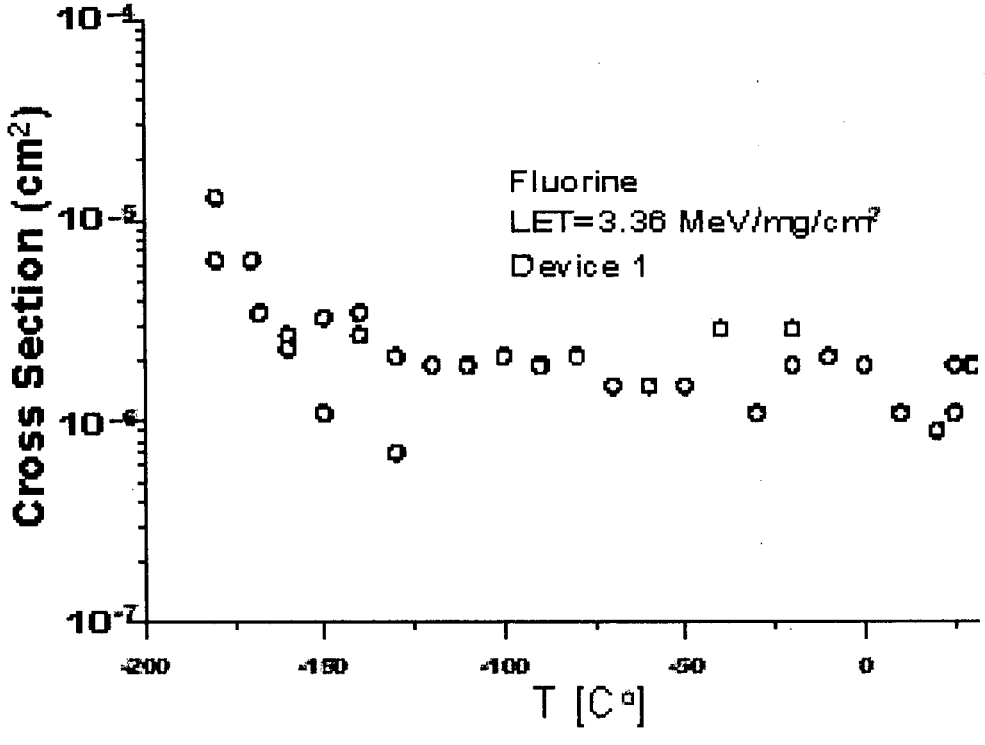
  Coldfinger

- Combination

  LN2 line to DUT

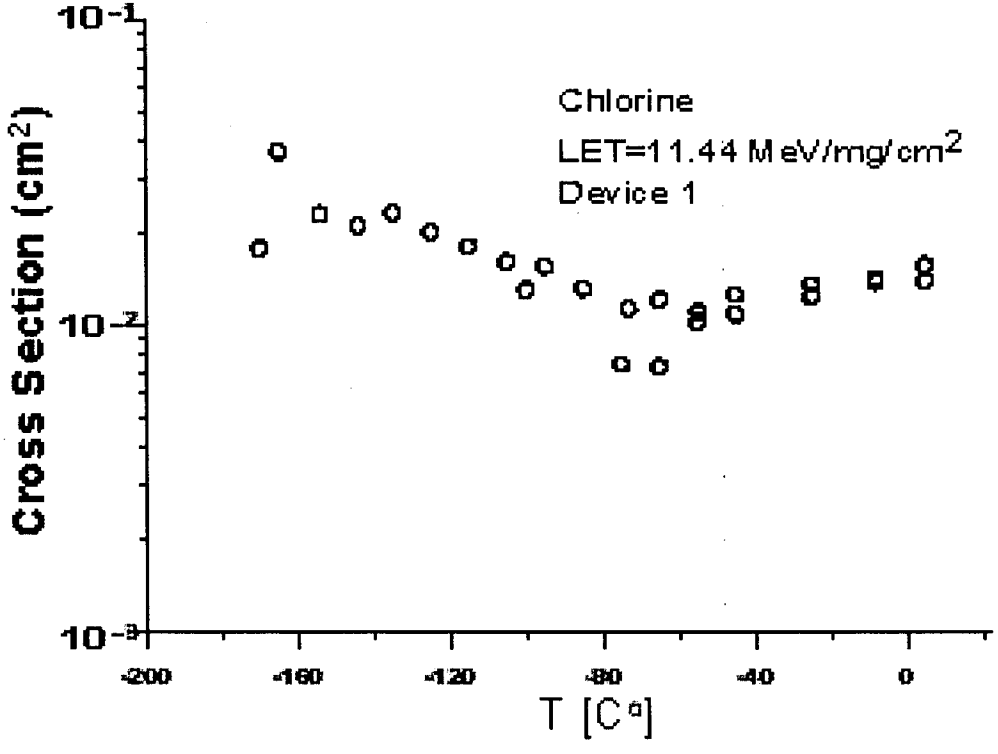


Result(s):



Temperature effects on cross-section of a WMS128k8 SRAM.

Result(s):



Temperature effects on cross-section of a WMS128k8 SRAM.

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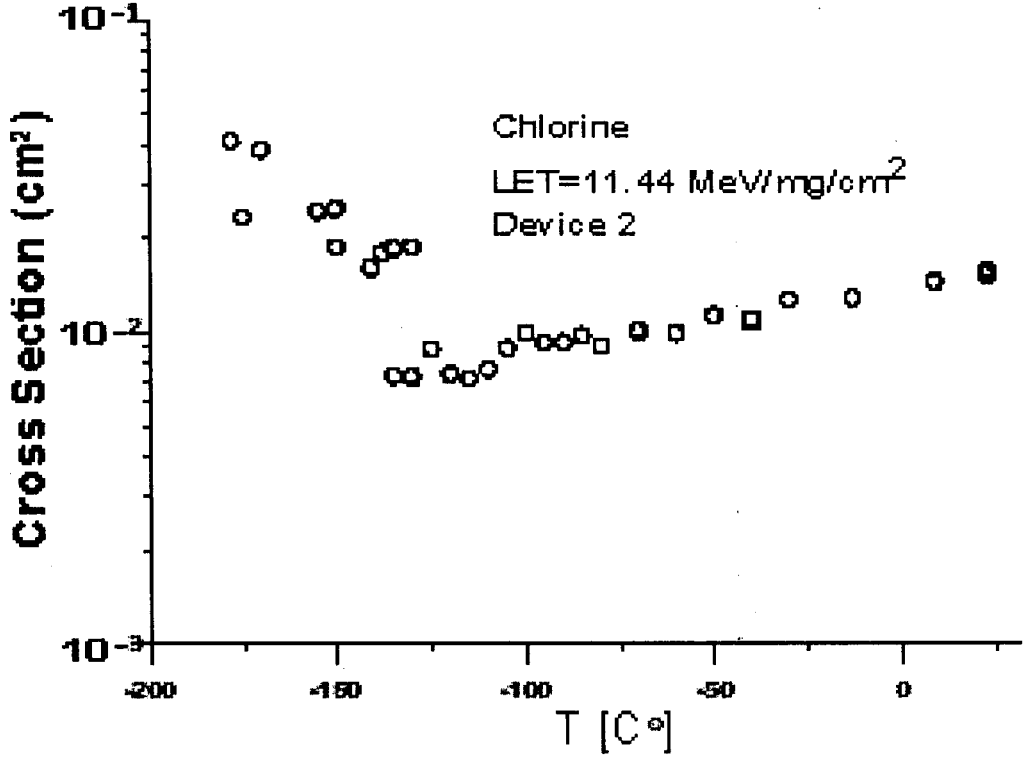

Temperature effects on cross-section of a WMS128k8 SRAM.

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