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ANALYTICAL MODEL OF PROBE CARD PERFORMANCE AT ELEVATED TEMPERATURE

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Introduction

- Room temperature probe card models have been successfully utilized at PTC since '95 (ref. SWTW'95).
  - contact force,
  - scrub length,
  - mechanical stresses
  - contact resistance and life time prediction
- Elevated temperature probing presented several challenges:
  - no at-temperature outgoing probe card analyzer available
  - heat transfer parameters can vary with each customer's test set-up
  - mechanical loads from Pogo's and mounting configuration are more critical since temperature increase causes materials to get "weaker"
- Parametric Finite Elements have been utilized to create the analytical model to predict behavior of different probe card geometry
  - existing expertise
  - proven result accuracy at room temperature

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Topics of Discussion

- Model accuracy verification at Room Temperature
  - Prediction Vs. measurement of probe cards
    - Contact Force
    - Total Scrub length
- Elevated temperature model
    - Considered probe card geometry
    - Boundary conditions (heat transfer effects, mounting)
- Probe card elevated temperature performance analysis
    - Temperature distribution
    - Thermal deformation
    - Thermal stresses

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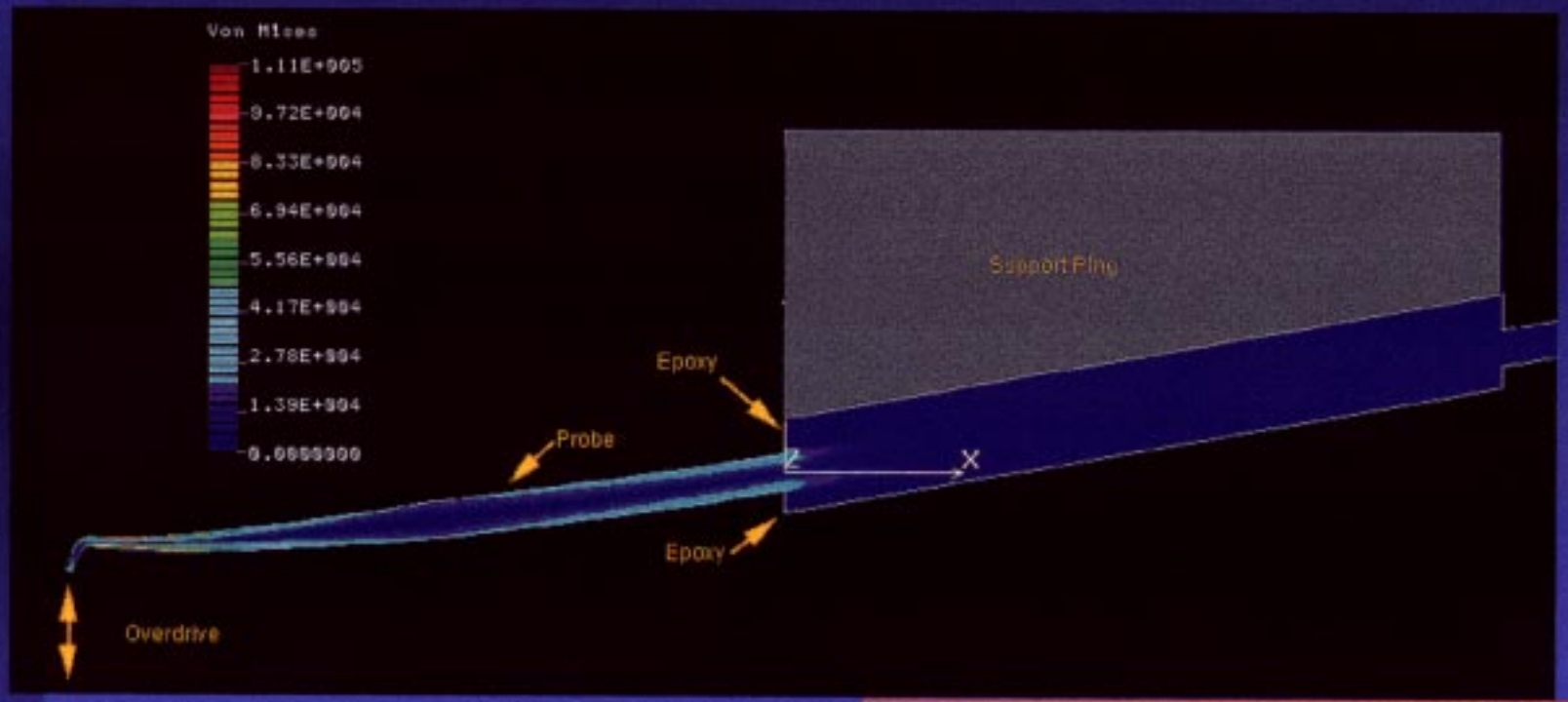
Mechanical Stresses and Deformation in Probe & Epoxy- Room Temperature



- Stresses superimposed on deformed probe and epoxy (PSI)

- Maximum stresses in Tungsten probe are safe at 0.003" deflection

- Maximum stresses in epoxy can exceed it's strength at 0.003" deflection

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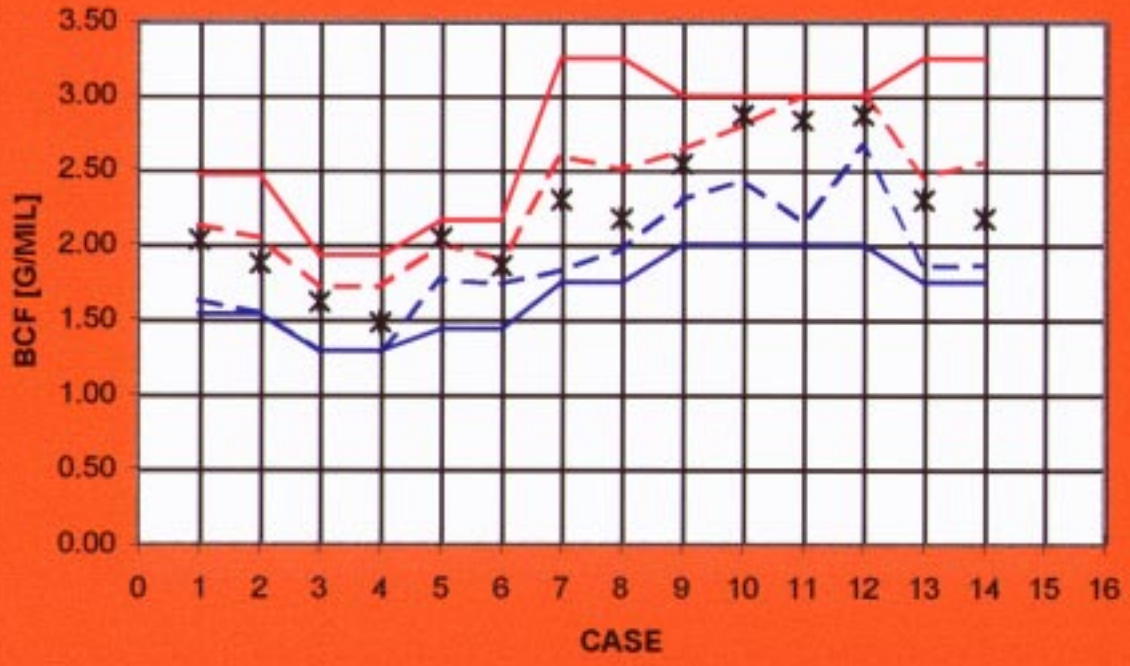
Contact Force Predicted by FEA Model for 14 Probe Configurations Used in Probe Card Manufacturing - Room Temperature.



14 different probe configurations

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Room Temperature Results

- Very good correlation between FE-model and measurement
  - Mechanical stresses in probe and epoxy due to 0.003" deflection
  - Measured Contact Force Vs. FEA model results for 14 different probe geometries used in probe card manufacturing.
  - Input/ Output Table for parametric FEA model
- Parametric model allows for efficient examination of many geometries- Fast Feedback to manufacturing.
- Fewer mistakes due to wrong beam length for desired contact force/ scrub length.

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Elevated Temperature Model

- Presented is modeled DRAM 6x4 Multi- Die Probe Card:
  - Advantest 5335 tester PCB platform; 10" Dia., .189" thickness
  - 4.0" x 1.0" probing area
  - Probe Depth 0.330"
  - 125 deg. C operating temperature (chuck)
- Individual Probe performance:
  - Thermal deformation
  - Mechanical stresses
- PCB/stiffener mechanical performance:
  - Temperature distribution
  - Thermal deformation
  - Thermal stresses

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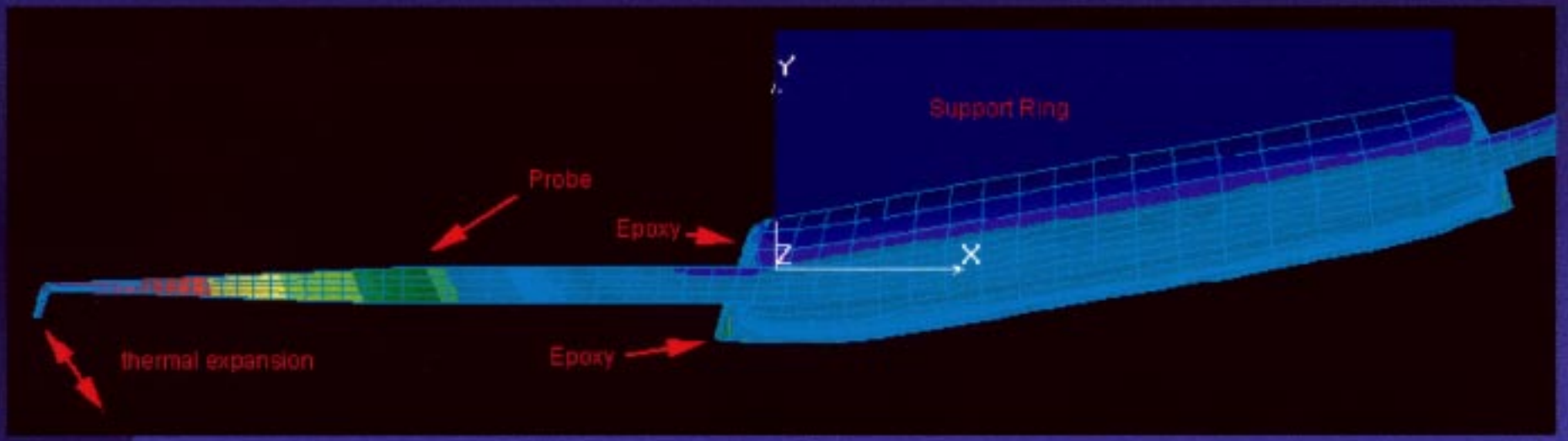
Thermal Deformation.

Probe and Epoxy Expansion



-Heat source from chuck

-Epoxy expansion bends probe upwards and out.

- Resultant probe tip movement ~0.0003"/ 100 C

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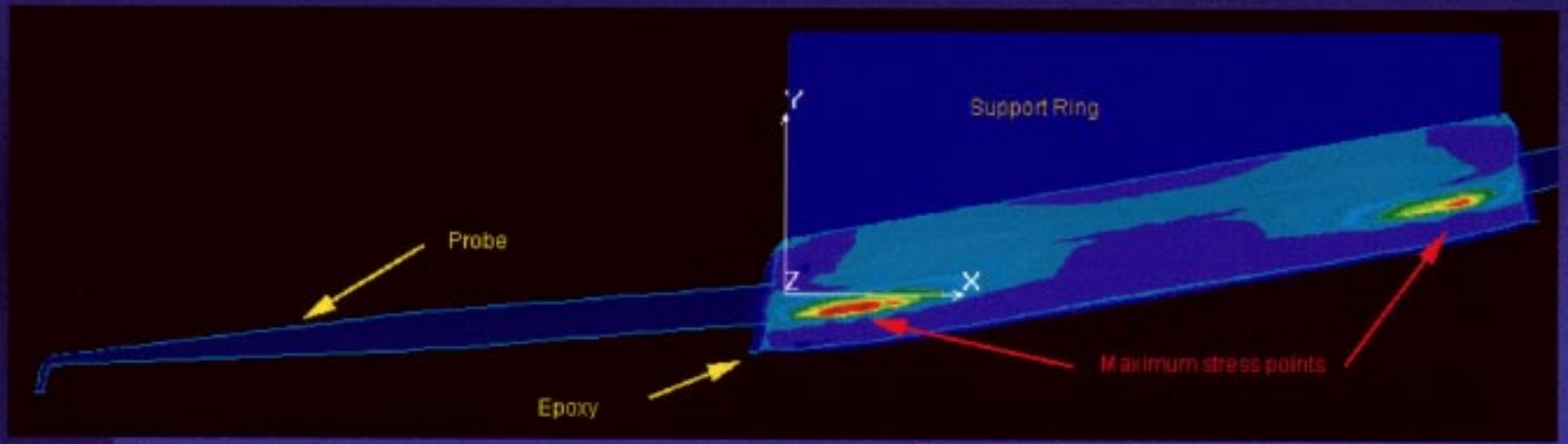
Thermal Stresses Due to Probe and Epoxy Expansion.



-Heat source from chuck

-Epoxy expansion bends probe upwards and out

- Highest Thermal stress is in tungsten probe & within yield strength.

- Epoxy stress is within yield strength.

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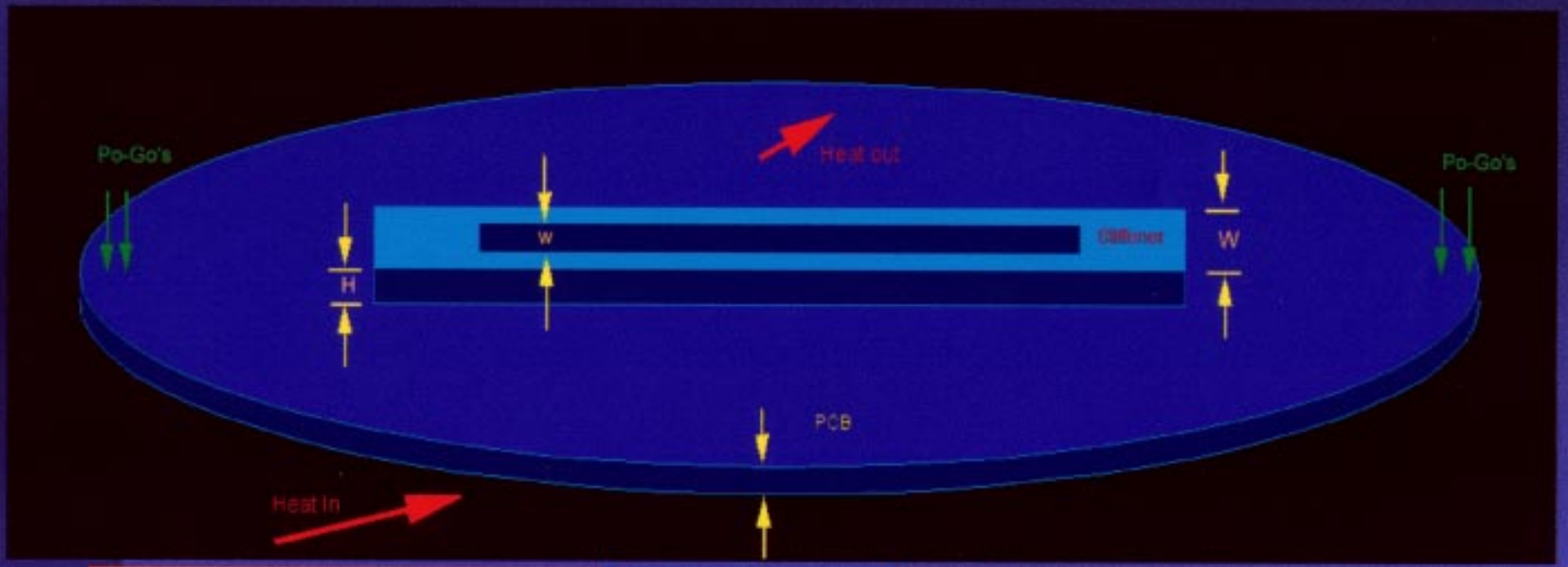
Probe Card Finite Element Model

Top View



- Model with optional stiffener
- External heat generation (Chuck)
- Pogo Pins clamp PCB perimeter

- Convection through air (in & out)
- Radiation to PCB bottom
- No Conduction through probes

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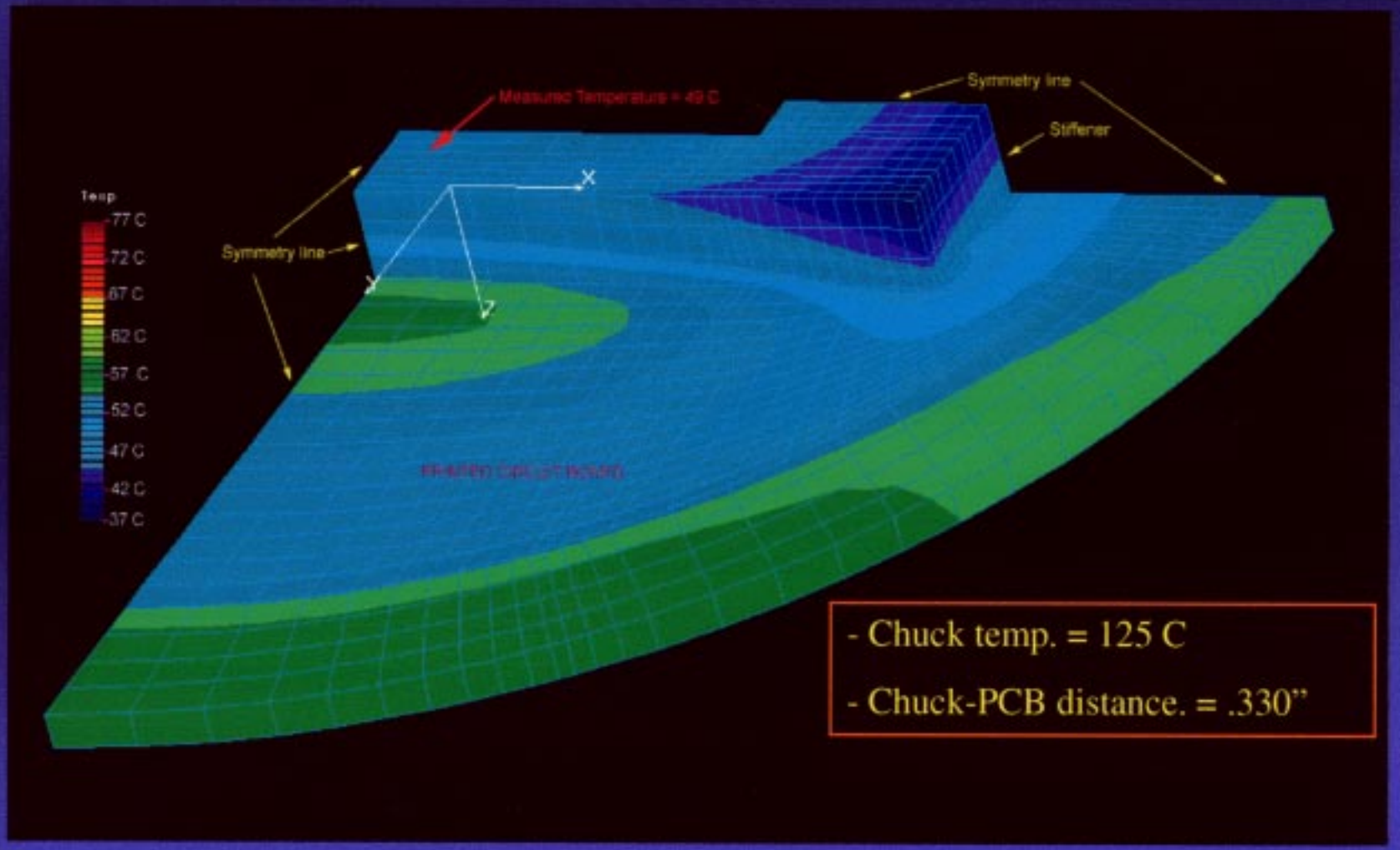
Temperature Distribution - Tester/Stiffener Side

View of 1/4 Geometry



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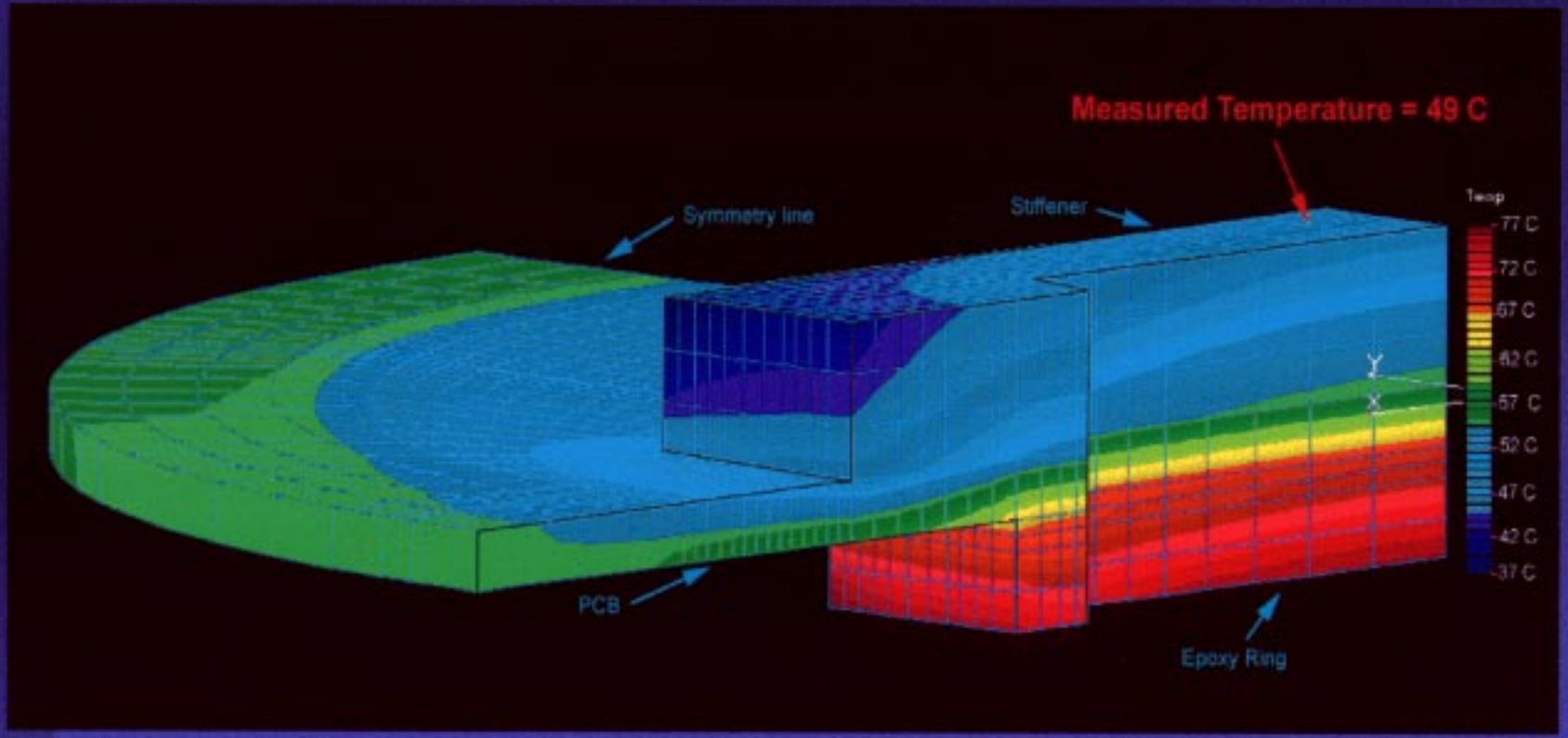
Temperature Distribution

1/4 of Probe Card Geometry



- Chuck temp. = 125 C
- Chuck-PCB dist. = .330"

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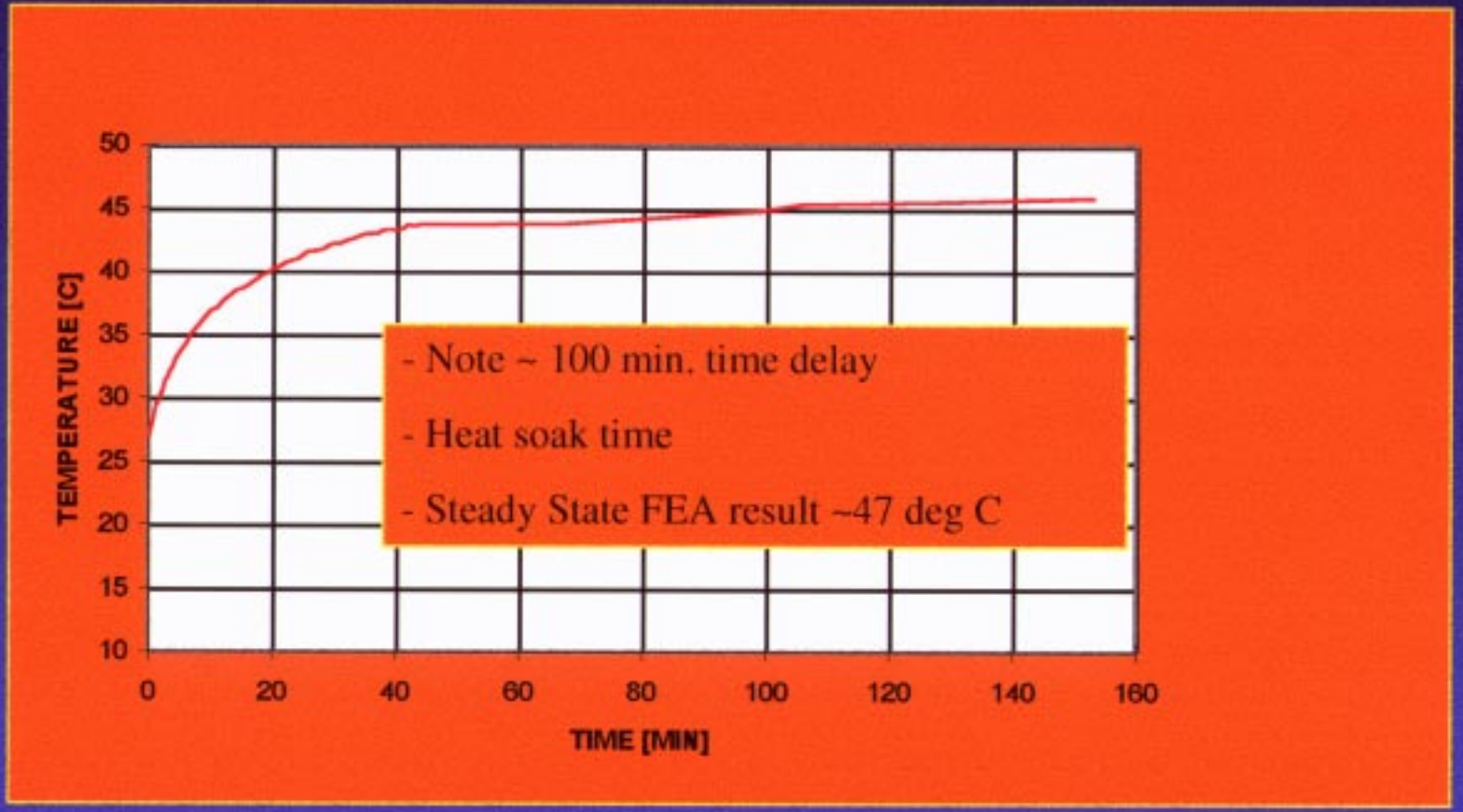
Temperature Increase in Probe Card as Measured on Top of PCB



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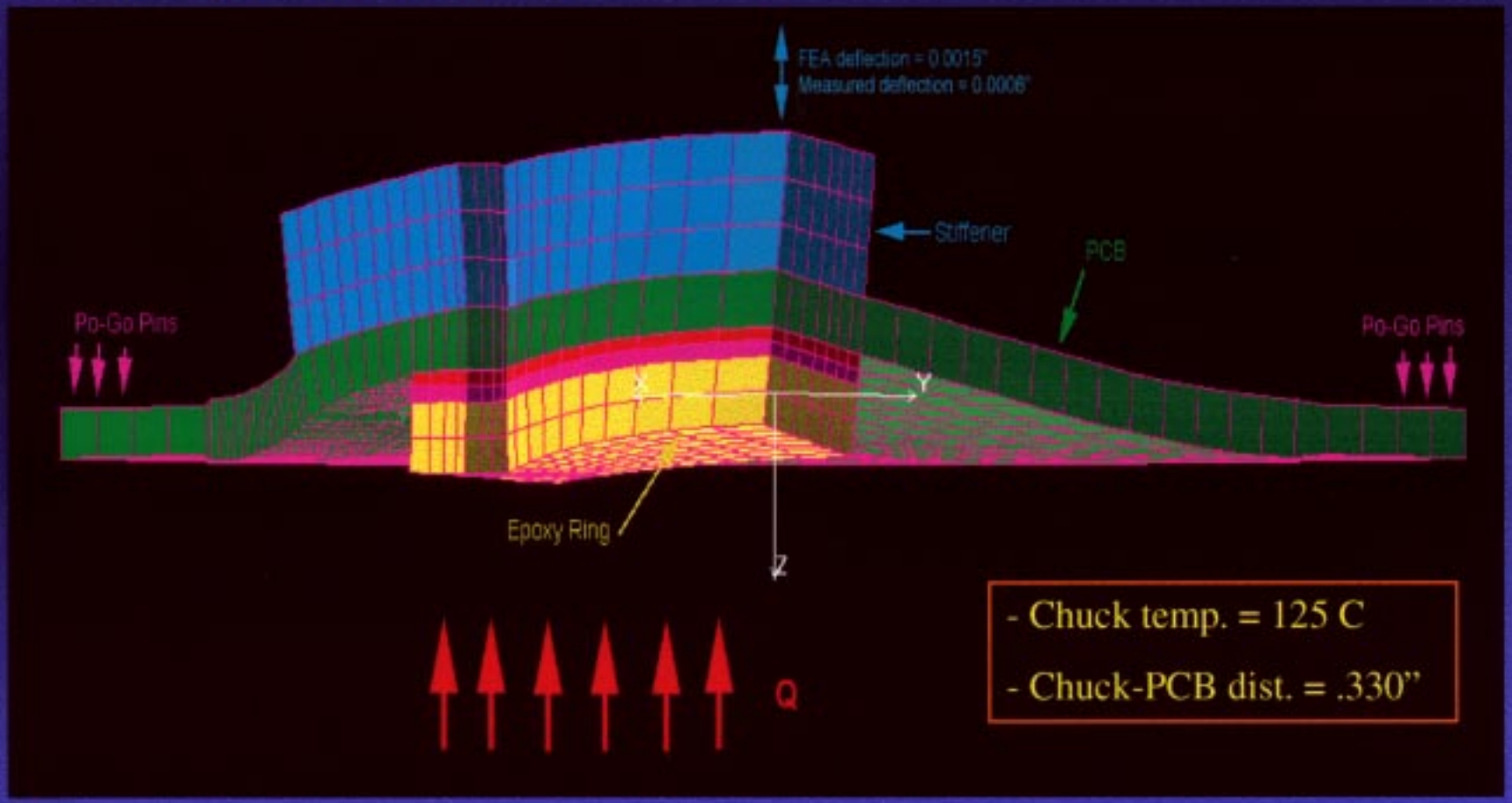
Probe Card Thermal Deflection

1/4 of Probe Card Geometry



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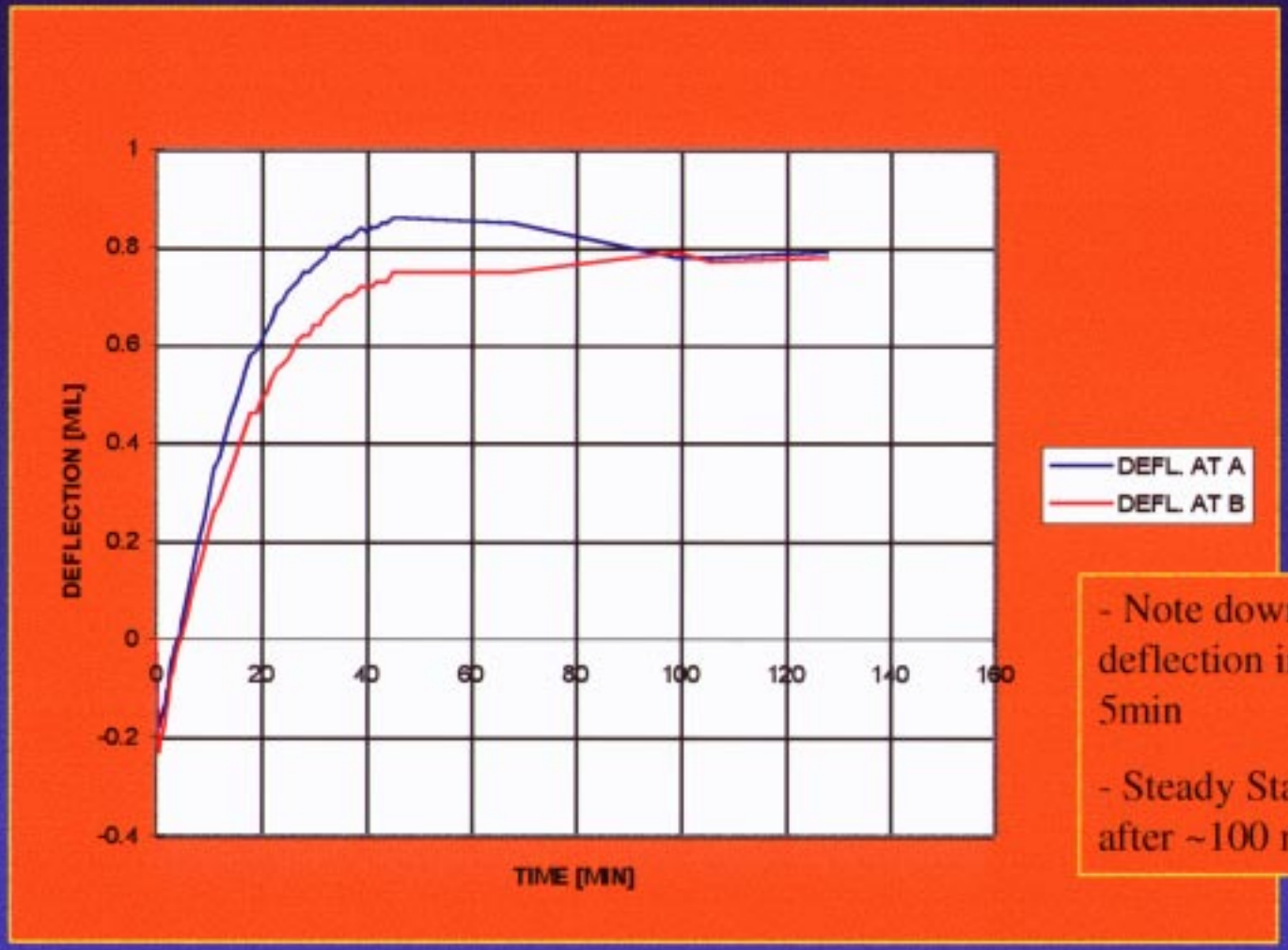
Transient Probe Card Deflection as Measured on Top of Stiffener (A) and Top of PCB (B)



- Note downward deflection in the first 2-5min

- Steady State achieved after ~100 min.

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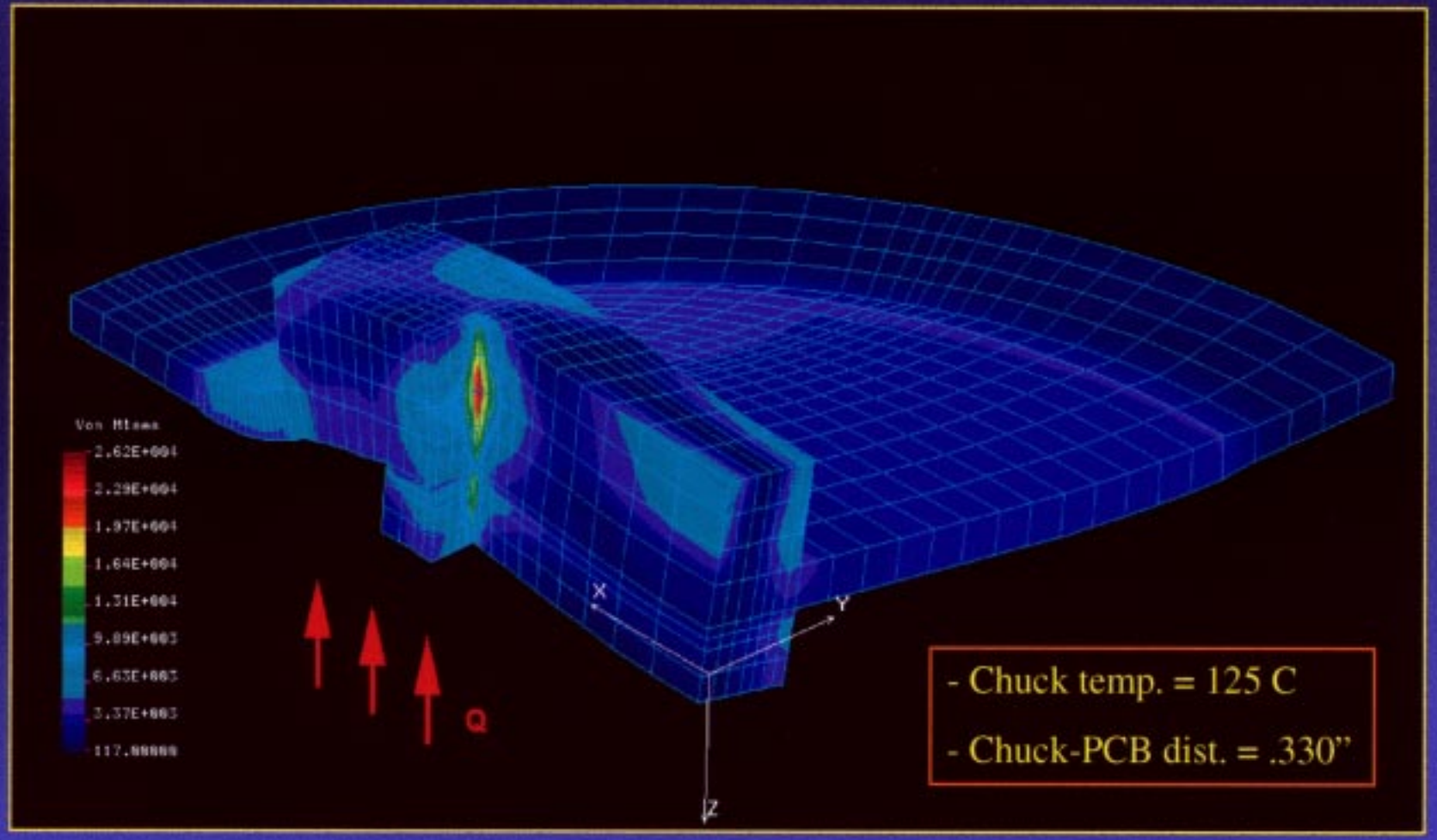
Probe Card Thermal Stresses

1/4 of Probe Card Geometry



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CONCLUSIONS:

- Presented Parametric FEA model offers insights into how probe cards perform mechanically at Room as well as Elevated temperatures in Steady State mode.
- Model accurately predicted:
  - Deflections
  - Temperature distribution
  - Stress/strain
  - Contact forces/ scrub length
- Parametric nature of the model allowed for fast analysis and selection of optimum stiffener/ support ring design with desired 0.0008" max. thermal deflection at 125 C.
- Future improvements of the model will include Transient Heat Transfer Analysis to enable predicting heat soak times for probe cards.