Heaters -Thermal Analysis of thin film heaters

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ELECTRO-THERMAL ANALYSIS OF THIN FILM HEATER

Heaters:

Heaters find great use in various products and industries. Two important industry are semiconductors and Satellites.
In Satellites, when in space, can reach sub-zero temperature. Electronic components can become brittle under such condition and tend to break. To avoid such breakages, heaters are provided around such electronic components to keep them in working condition. Similarly, they also find great use in Wafer technology where uniform heat distribution are desire around wafers to glue multiple layers. Its very important to maintain uniform temperature as the output product is sensitive to differential temperatures around the wafer.

Heaters used in above application are mostly Thin film heaters where a thin film made of several traces around is sandwiched between dielectric substrate to form heater.

FEA software's can be used to simulate entire functionality even before physical prototyping and are cost effective solution.
Joule heating is simulated in FEA software where a potential difference is maintained between two end of Traces and heat produced due to passage of current can be accurately computed in the FEA softwares. AES specializes in design of such Heaters.

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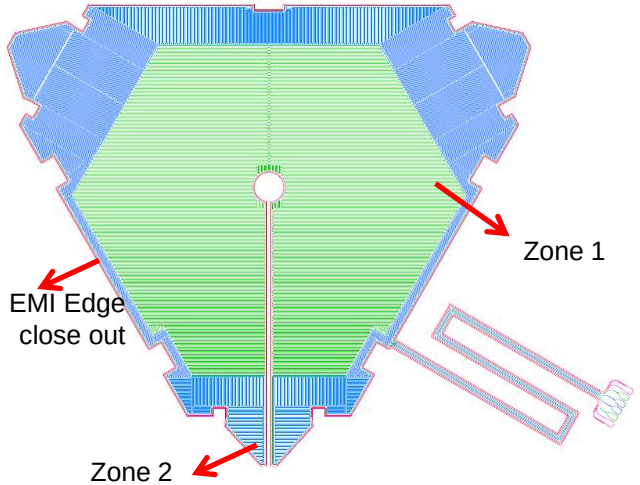
Objective:

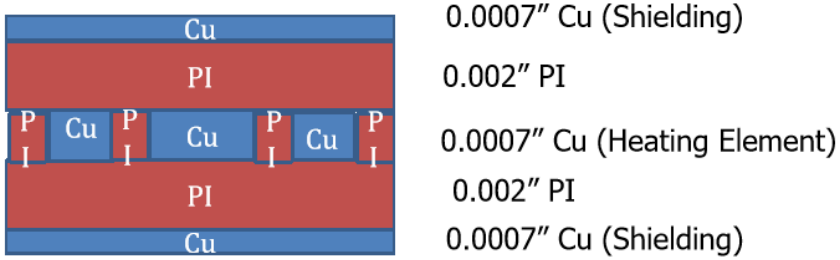
To arrive at Trace width and perform layout optimization for Meeting resistance requirement of a heater for **FRALOCK**. To perform Thermal study for Dielectric test requirement with test voltage and current.

To validate thermal uniformity at normal use case.



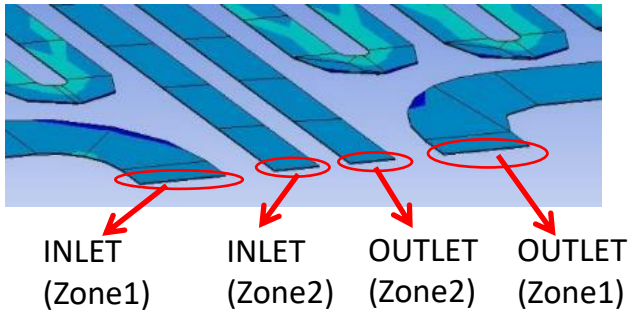
The three simulations required to design a heater are as follows:

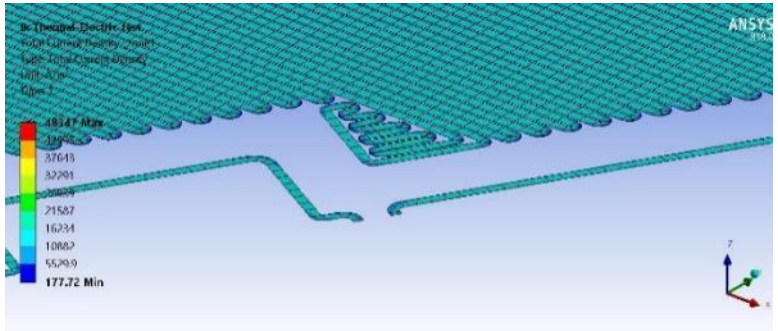
- **Layout optimization to meet resistance requirement.**
- **Dielectric test to confirm the thermal stresses are within the allowable limit of dielectric material.**
- **Normal use test where we confirm that the temperatures are uniform across the area of the heater upon heating in steady state.**

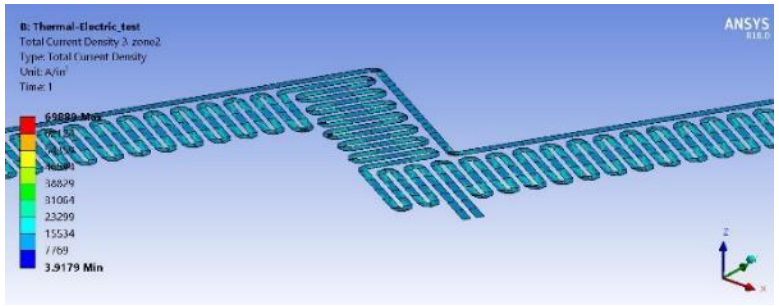


ELECTRO-THERMAL ANALYSIS OF THIN FILM HEATER

Zone 1 actual length =L	3467	in
Actual width = W	0.0556	in
Trace thickness=T	0.0007	in
Resistivity=ρ	7.73E-07	ohm.in
Resistance R=ρxL/(WxT)	68.87	ohm
Voltage input	30.00	V
Current output	0.43559475	Amp
Current Density	11194.0674	Amp/in^2
Zone 2 actual length =L	2542	in
Actual width = W	0.0291	in
Trace thickness=T	0.0007	in
Resistivity=ρ	7.73E-07	ohm.in
Resistance R=ρxL/(WxT)	96.46	ohm
Voltage input	30.00	V
Current output	0.31099775	Amp
Current Density	15267.4397	Amp/in^2



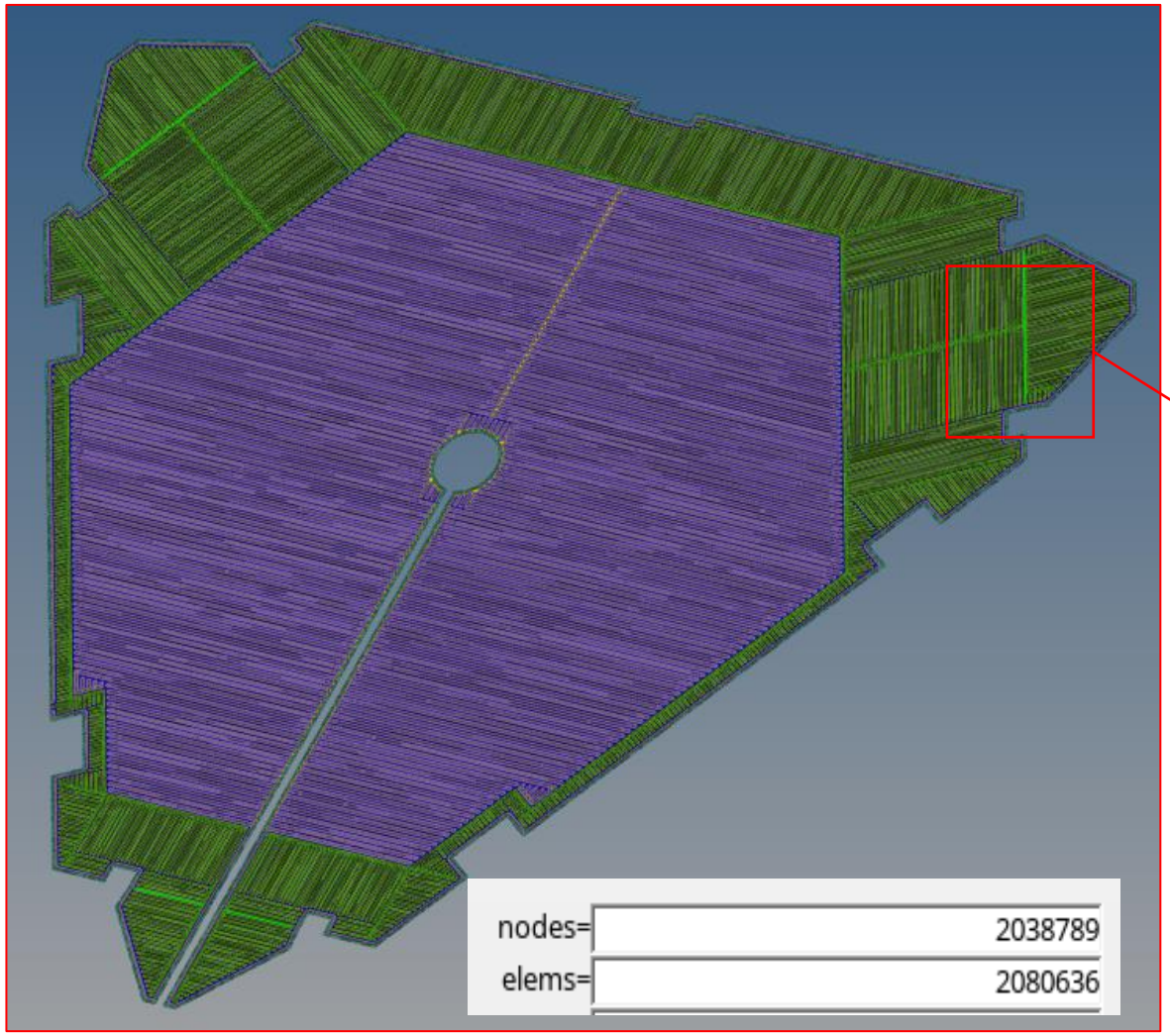


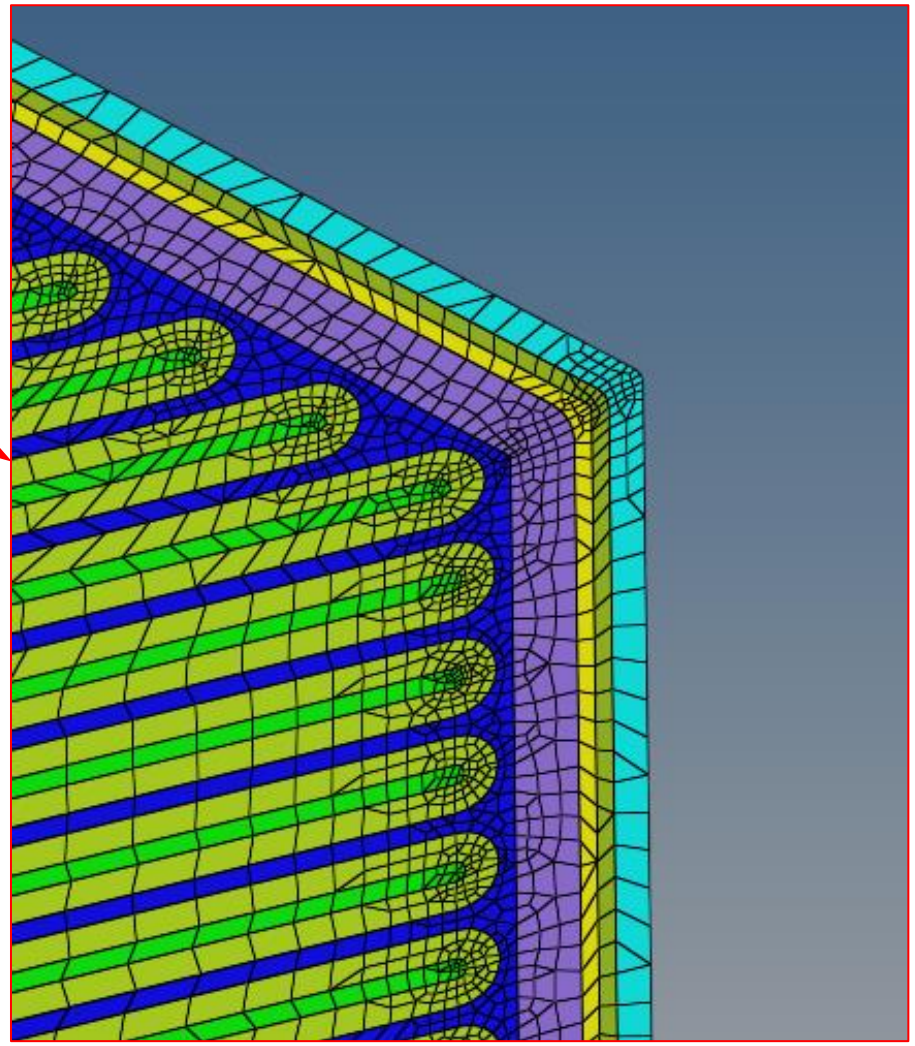


- Current density in zone 1 is **12385 A/in²**
- Current density in zone 2 is **15440 A/in²**

- Simulation done by updating resistivity of copper as 7.731e-7 ohm-in.
- Resistance in Zone 1 is 62.19 ohms & Resistance in Zone 2 is 95.39 ohms
- From manual calculation, Zone 1 resistance is 68.88 ohms and Zone 2 resistance is 96.48ohms.
- It is found that both the resistances satisfy the requirement of 70+-10 ohms for zone 1 and 98 +/-10 ohms.

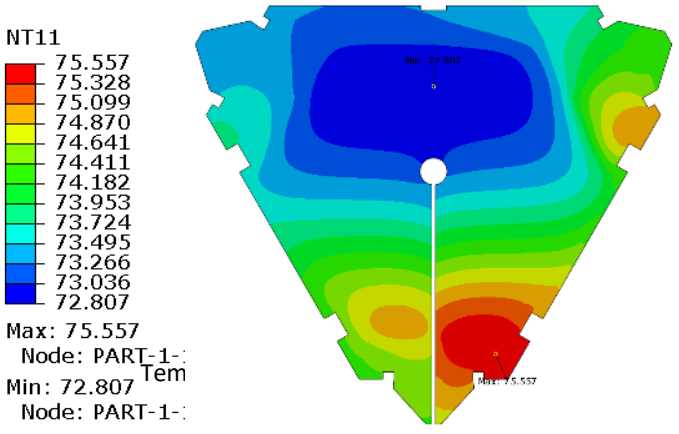
GEOMETRY & MESH



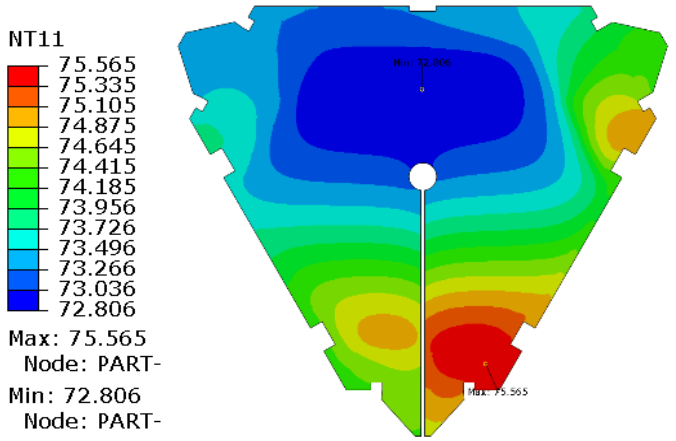


THERMAL AND ELECTRICAL PLOTS

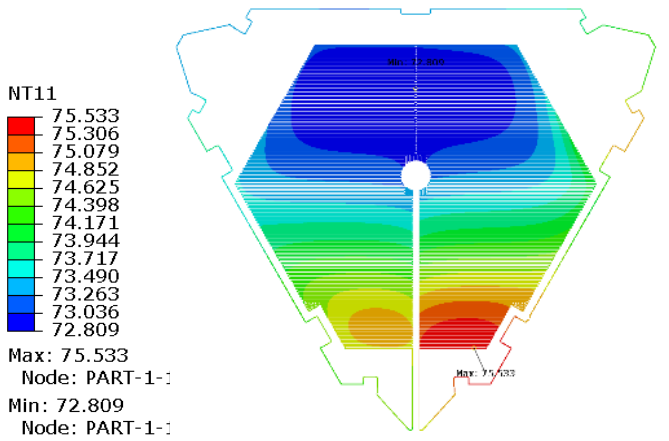
TEMPERATURE PLOT FOR TOP COPPER LAYER



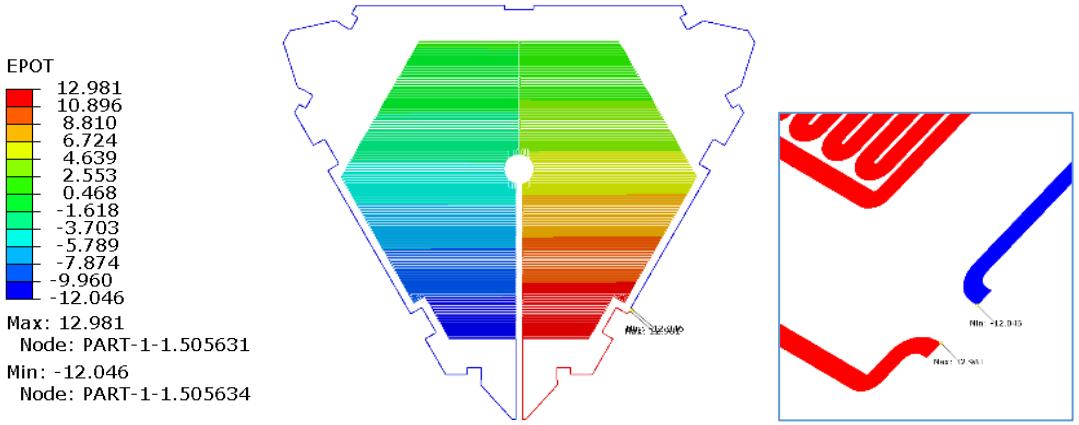
TEMPERATURE PLOT FOR POLYMIDE



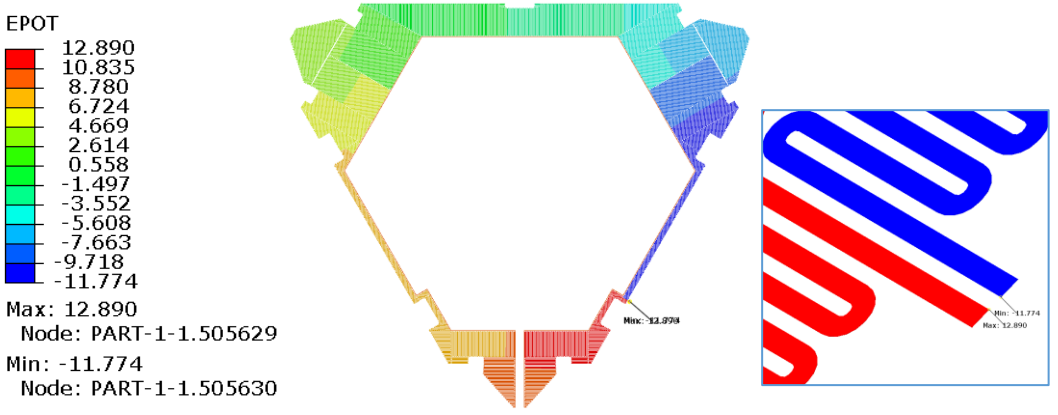
TEMPERATURE PLOT FOR CU TRACE IN ZONE 1



ELECTRICAL POTENTIAL PLOT FOR ZONE 1



ELECTRICAL POTENTIAL PLOT FOR ZONE 2



CONCLUSION

- Maximum temperature found in the heater coil assembly ranging between 75.6 -72.8 ^{0}F and is nearly uniform over the entire volume. Net rise of 4 ^{0}F observed.
- The comparison of surface temperatures between the analytical value and the simulation value is fairly matching.
- Voltage difference between inlet and outlet is 25 V in Zone 1.
- Voltage difference between inlet and outlet is 24.7 V in Zone 2.
- Solve done using first order and second order but both fetched same results.
- Difference in the analytical and FEA calculation is due to fact that current leakage happening through polyamide.
- Analytical results found to be close to test results and varied within a range of +-5%.

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THANK YOU