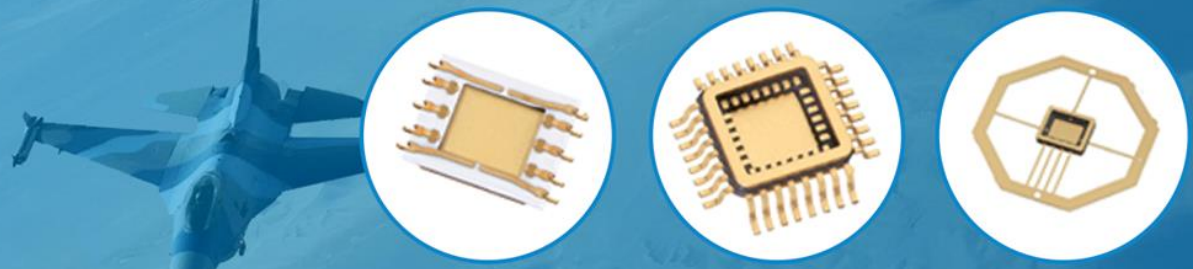

Package and Die Attach Comparisons for High Power GaN Devices

StratEdge Corporation
Casey Krawiec and Erik Sanchez

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High Frequency
High Speed
High Power

Company Snapshot

- StratEdge founded in 1992
- Focus on compound semiconductors
- Packages and assembly services for RF, microwave, and millimeter wave devices
- Headquarters and manufacturing facility in San Diego
- Private corporation
- ISO 9001-2015 certified facility

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StratEdge Package Technology

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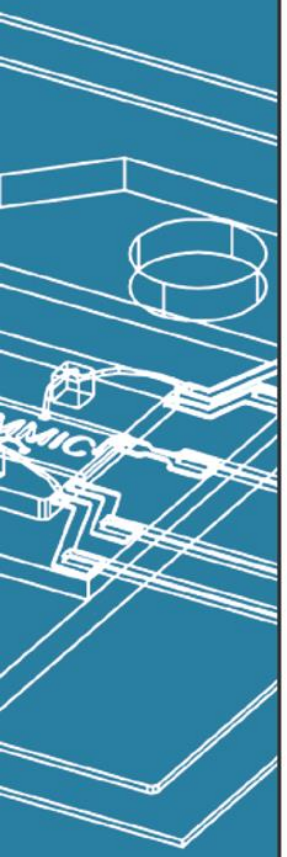
High Speed
High Power



Materials:

- Packages made from hardened ceramic substrates
  - Post-fired metallization of ceramic with thick film pastes
  - Alumina, Beryllium Oxide ceramics – laser machined
- Molded ceramic packages
  - Crack resistant alumina-filled glass
  - Fe-Ni-Co leads, bases, and rings for hermetic sealing
- Addition of high thermal conductivity base materials
  - CuW, CuMo, CMC laminate

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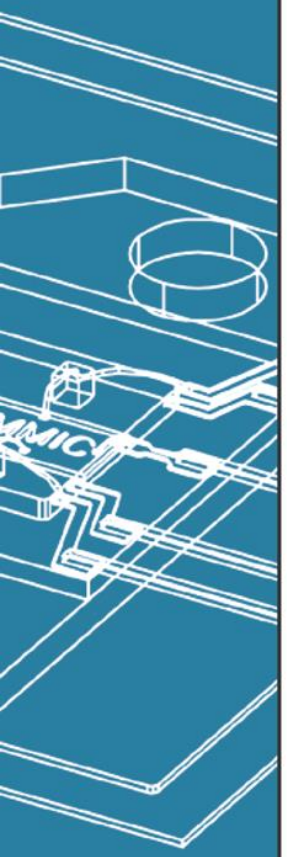
Thermal Analysis

High Frequency
High Speed
High Power



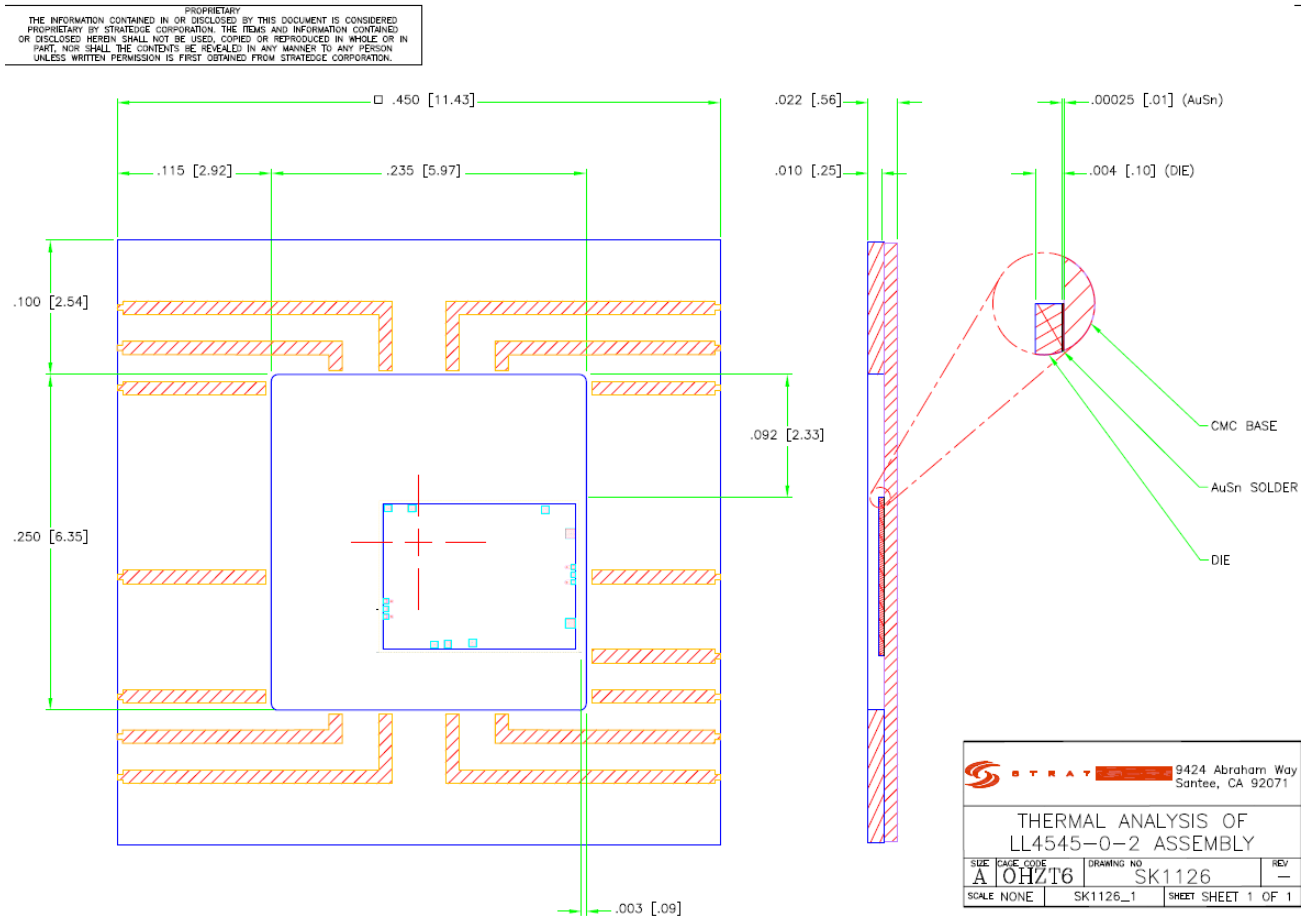
Objective: Conduct a series of thermal simulations to compare how well heat is dissipated from a Gallium Nitride device while varying the die attach material and package heat spreader (base) material.

Package and Chip Assembly

High Frequency
High Speed
High Power

Package Description:

- SE50 family
  - DC – 63 GHz
- Metal heatsink
- Alumina RF/DC layer
- High-temp braze
- Sealed with LCP cup-shaped lid with b-stage epoxy (not shown)



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Base Requirements for High-power Device

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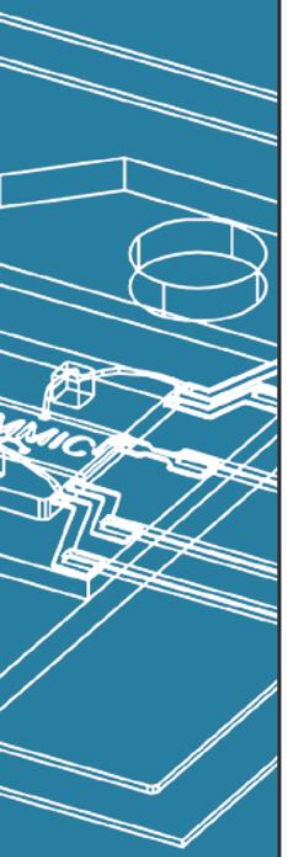
High Speed
High Power



High Thermal Conductivity

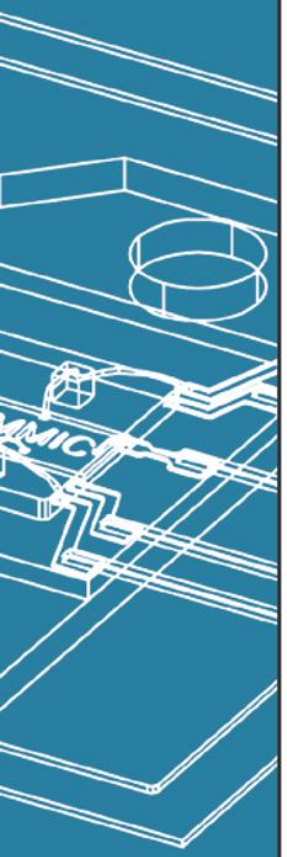
- Gallium Nitride (GaN) chips operating at high frequencies with high power generate heat that needs to be dissipated

Compatible Coefficient of Thermal Expansion (CTE)

- As the package heats up during operation, the base needs to expand close to the same rate as the GaN chip to prevent physical damage

Package Bases Studied

High Frequency
High Speed
High Power



CMC laminate

- Molybdenum layer between copper
- Cu:Mo:Cu 1:3:1 Thickness Ratio

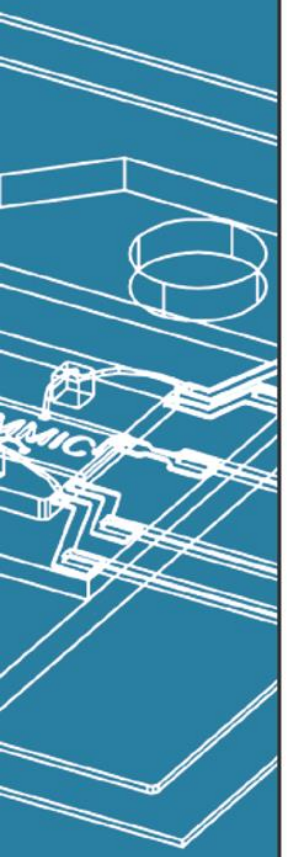
CuW (85/15)

- Copper tungsten composite
- 15% Copper / 85% Tungsten

CMC Base, Thermal Conductivity Layer Thickness (inches)	CuW Base, Thermal Conductivity, Layer Thickness (inches)
Copper (401 W/m K), 0.002	CuW (190 W/m K), 0.010
Mo (139 W/m K), 0.006	
Copper (401 W/m K), 0.002	

Die Attach Material

High Frequency
High Speed
High Power



EPO-TEK® H20E

- Silver-filled epoxy system

AuSn Eutectic Solder

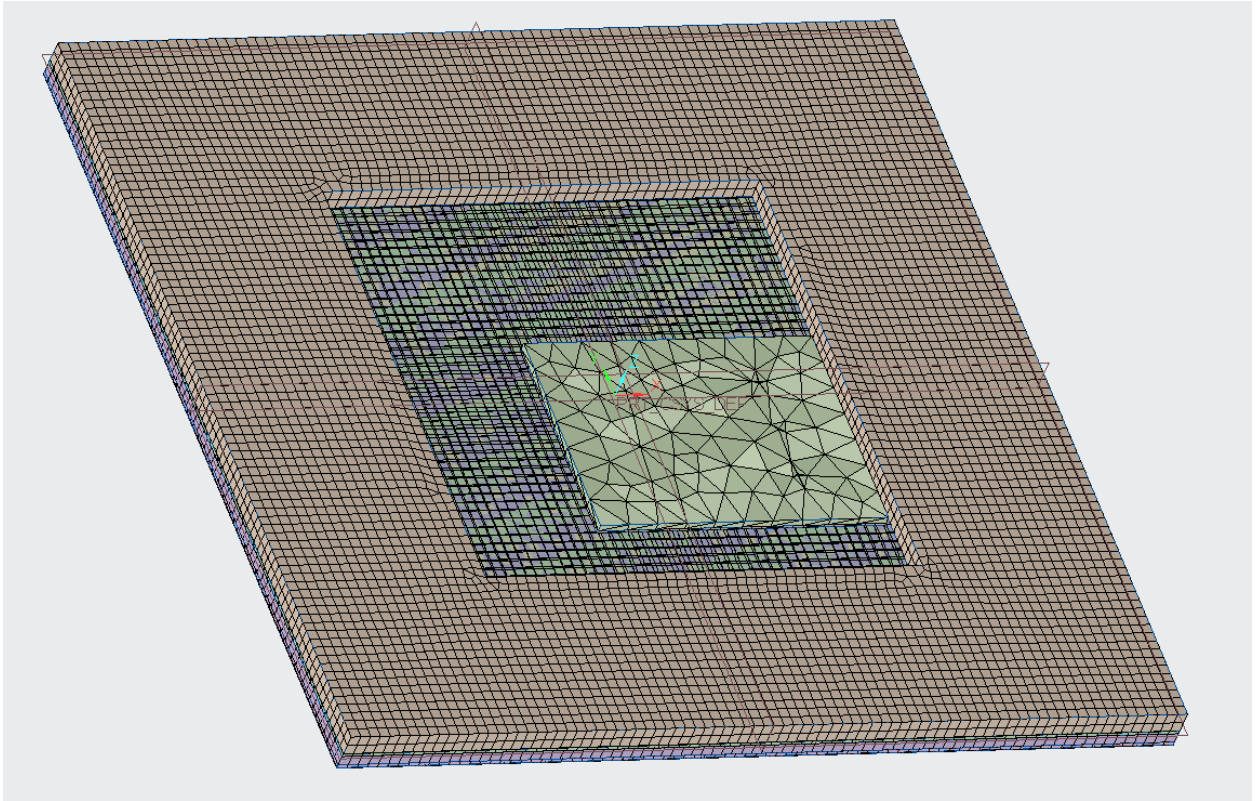
- 80% gold 20% tin

	EPO-TEK® H20E	**AuSn**
Bond Line Thickness (inches)	0.0015	0.00025
Thermal Conductivity (W/m K)	2.5	57

Simulation Software: PTC Creo Ansys

High Frequency
High Speed
High Power

- Creo Ansys Simulation is a finite element tool we used to evaluate thermal performance of a microelectronic system.
- Creo Ansys is a partnership between PCT and Ansys.



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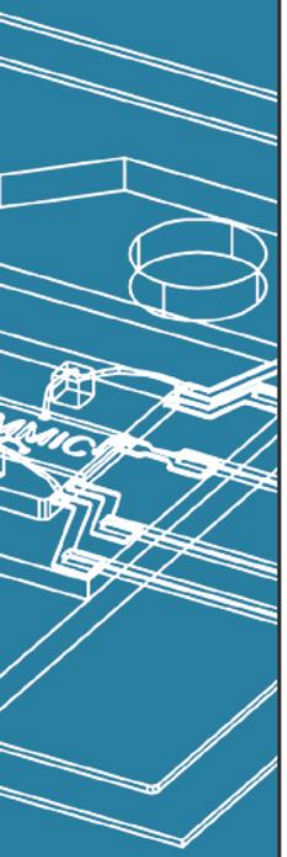
Steady State Thermal Analysis of a GaN Device

High Frequency
High Speed
High Power



GaN device, 0.150” long x 0.113” wide

- 10 Watts dispersed over the area of three output stages
- Each output stage generates 3.333 W
- Each output stage broken up into eight heat sources
- Heat generated is applied at the top surface of the GaN-on-Silicon Carbide (SiC) device

Boundary condition

- The bottom edges of the package are set at a constant temperature

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Steady State Thermal Analysis of a GaN Device

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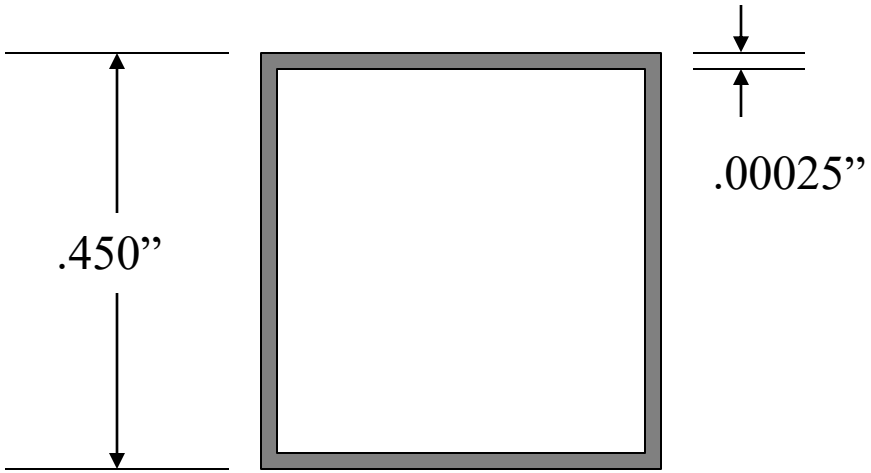
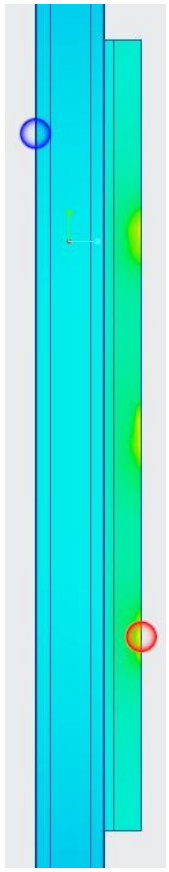
- Boundary condition: Area between 0.4495” x 0.4495” and 0.45” x 0.45” (base outer dimensions)
- Perimeter is set at 75°C

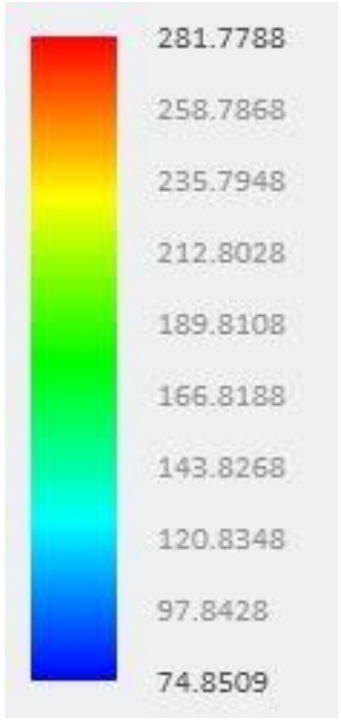


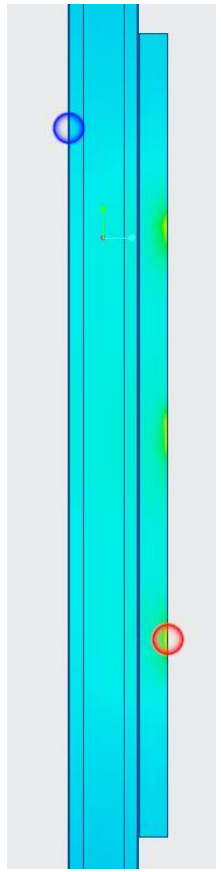
Visual Comparison of Temperature Gradients

High Frequency
High Speed
High Power

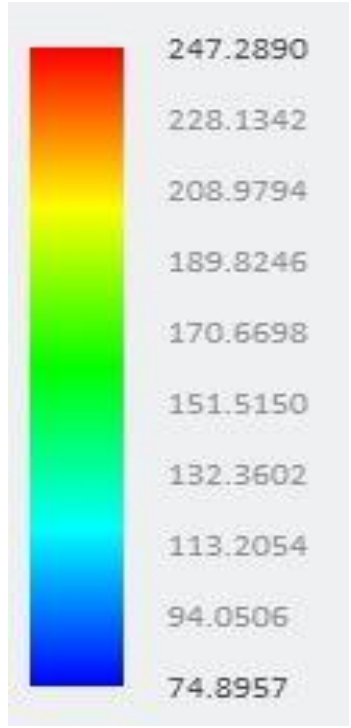


CuW with H20E





CMC with AuSn



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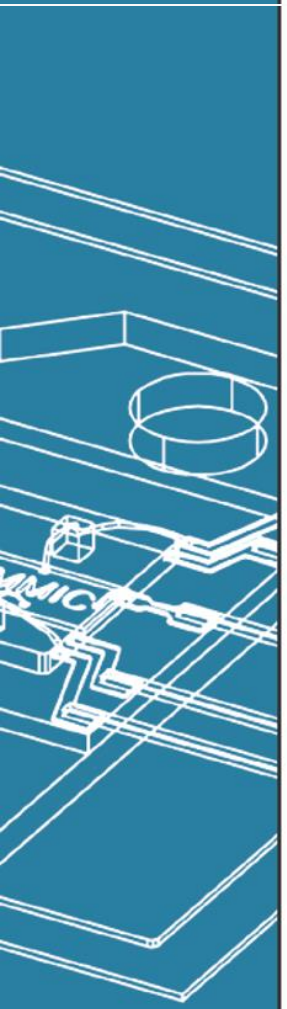
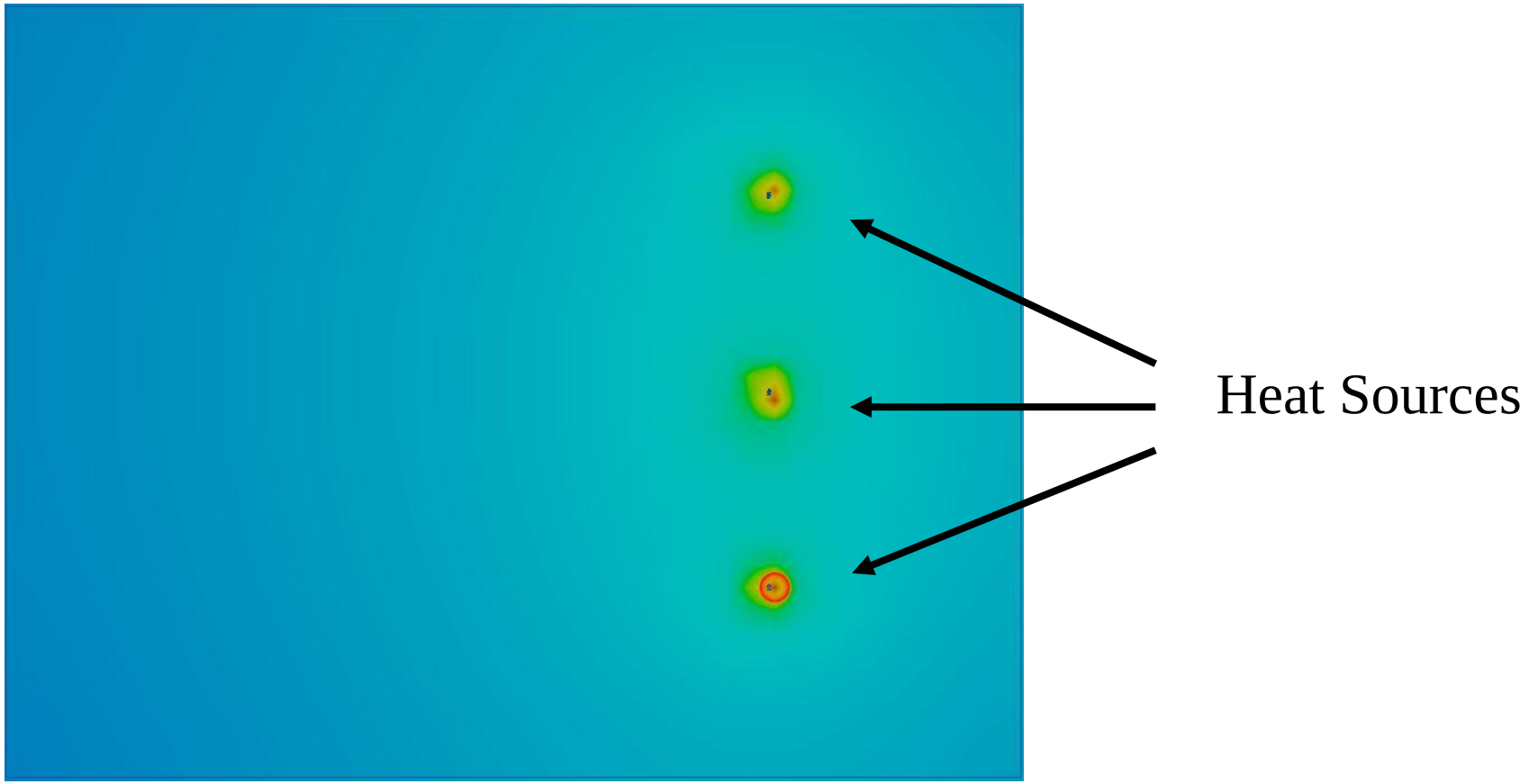
Heat Sources on Die

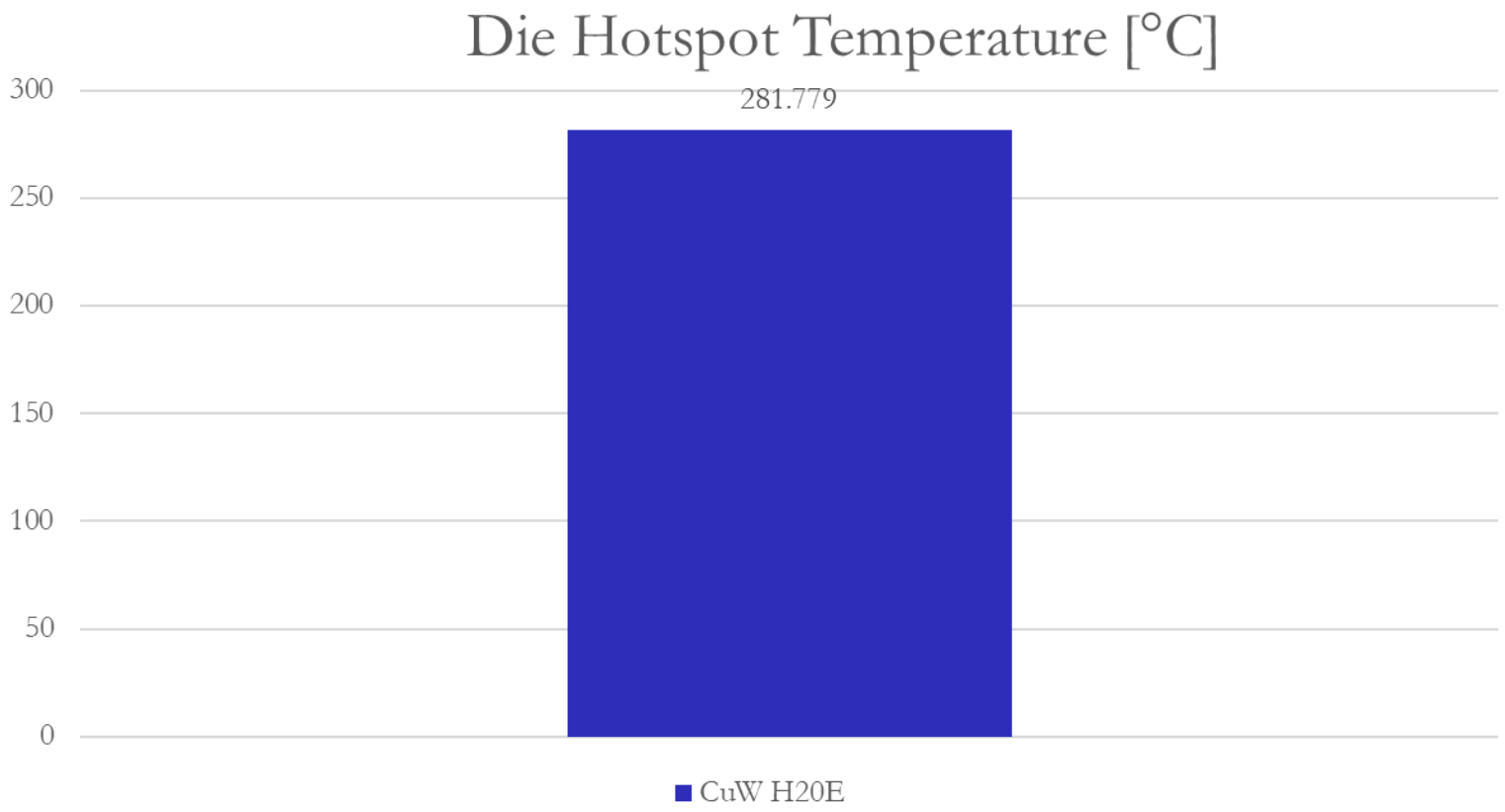
High Frequency
High Speed
High Power





Results: H20E on CuW Base

High Frequency
High Speed
High Power



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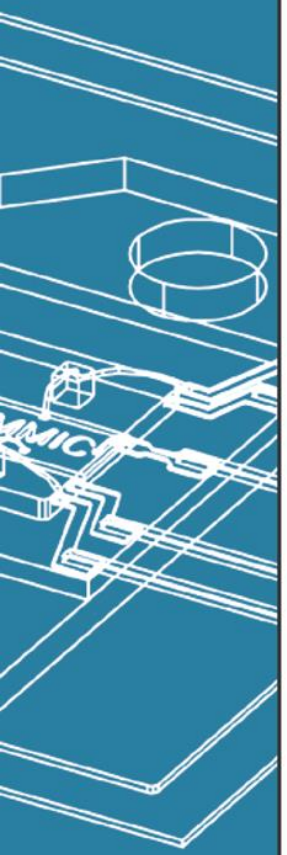
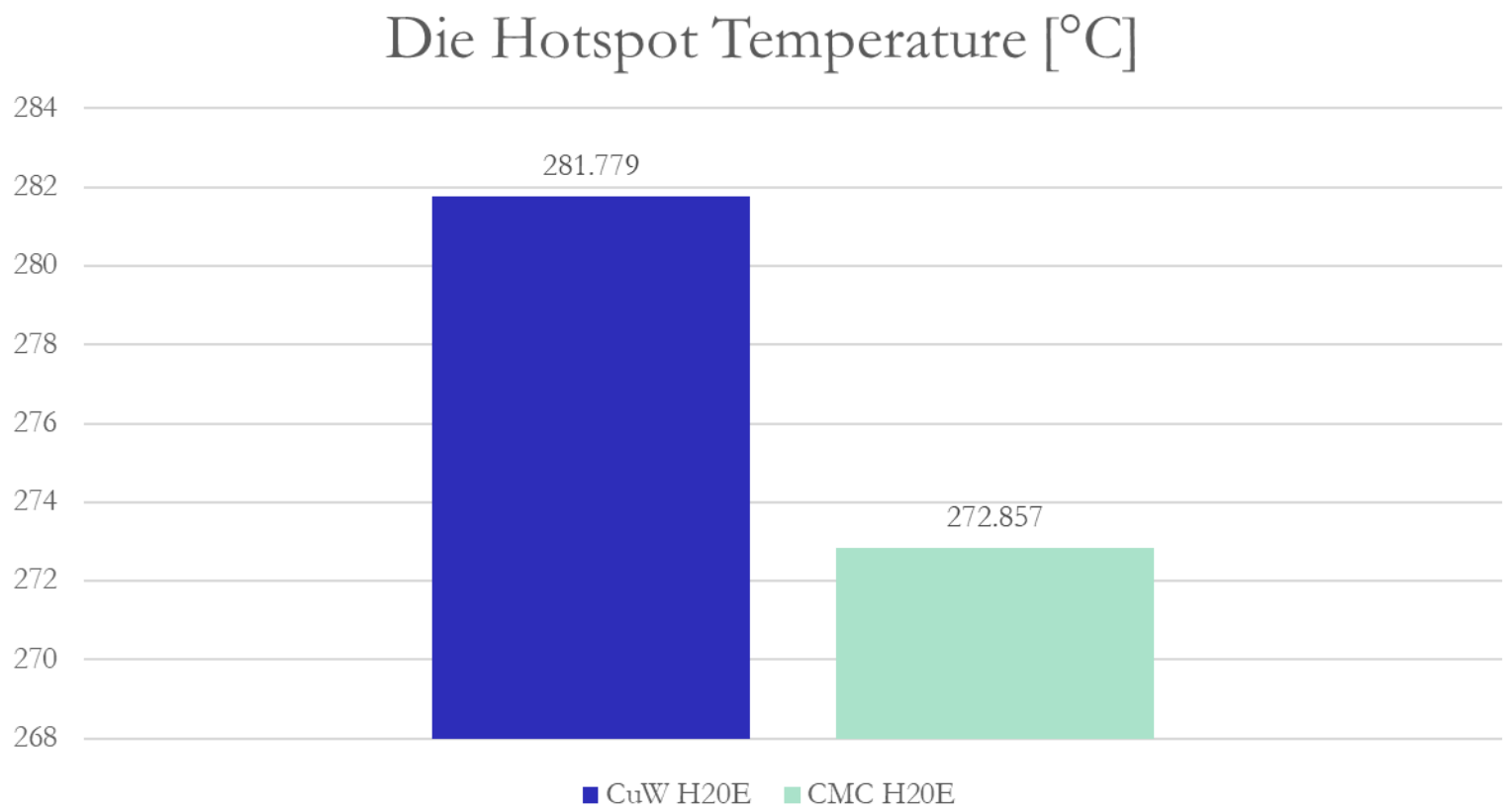
Results: H20E on CuW and CMC

High Frequency
High Speed
High Power





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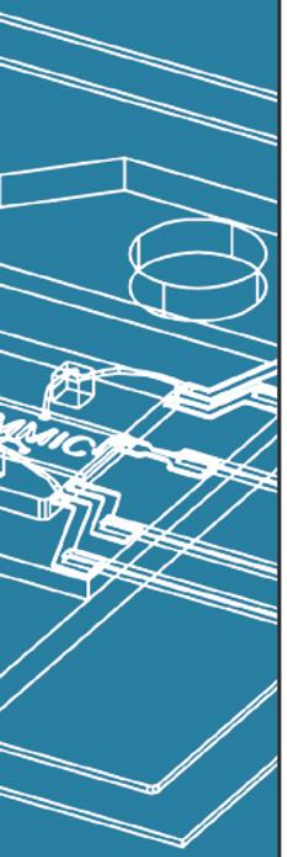
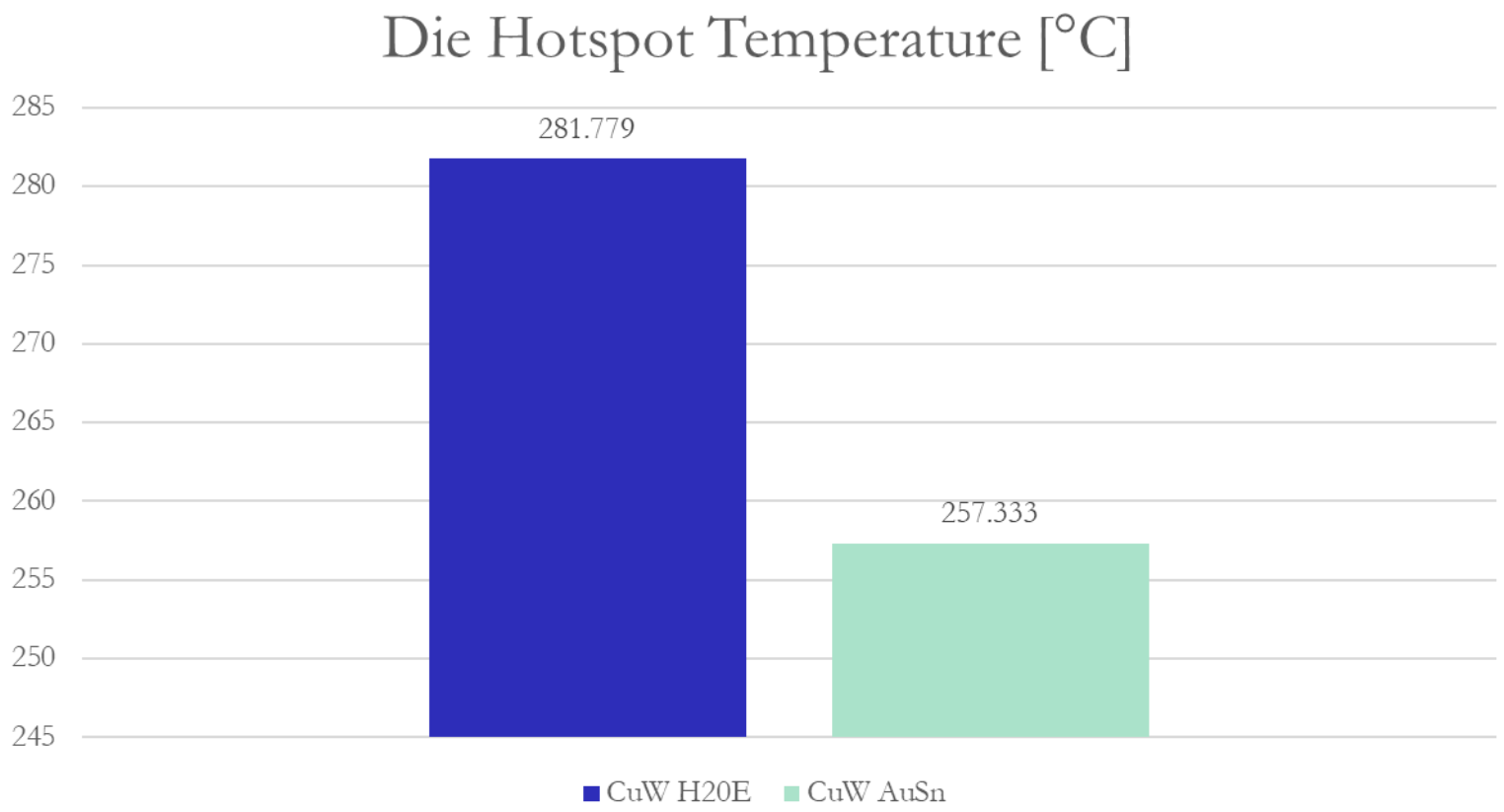
Results: H20E and AuSn on CuW

High Frequency
High Speed
High Power





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Results: H20E on CuW vs. AuSn on CMC

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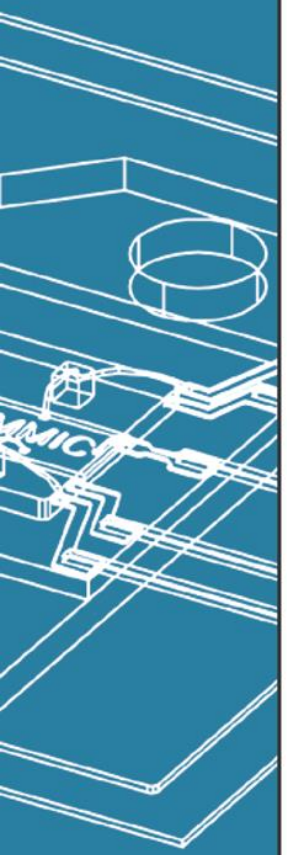
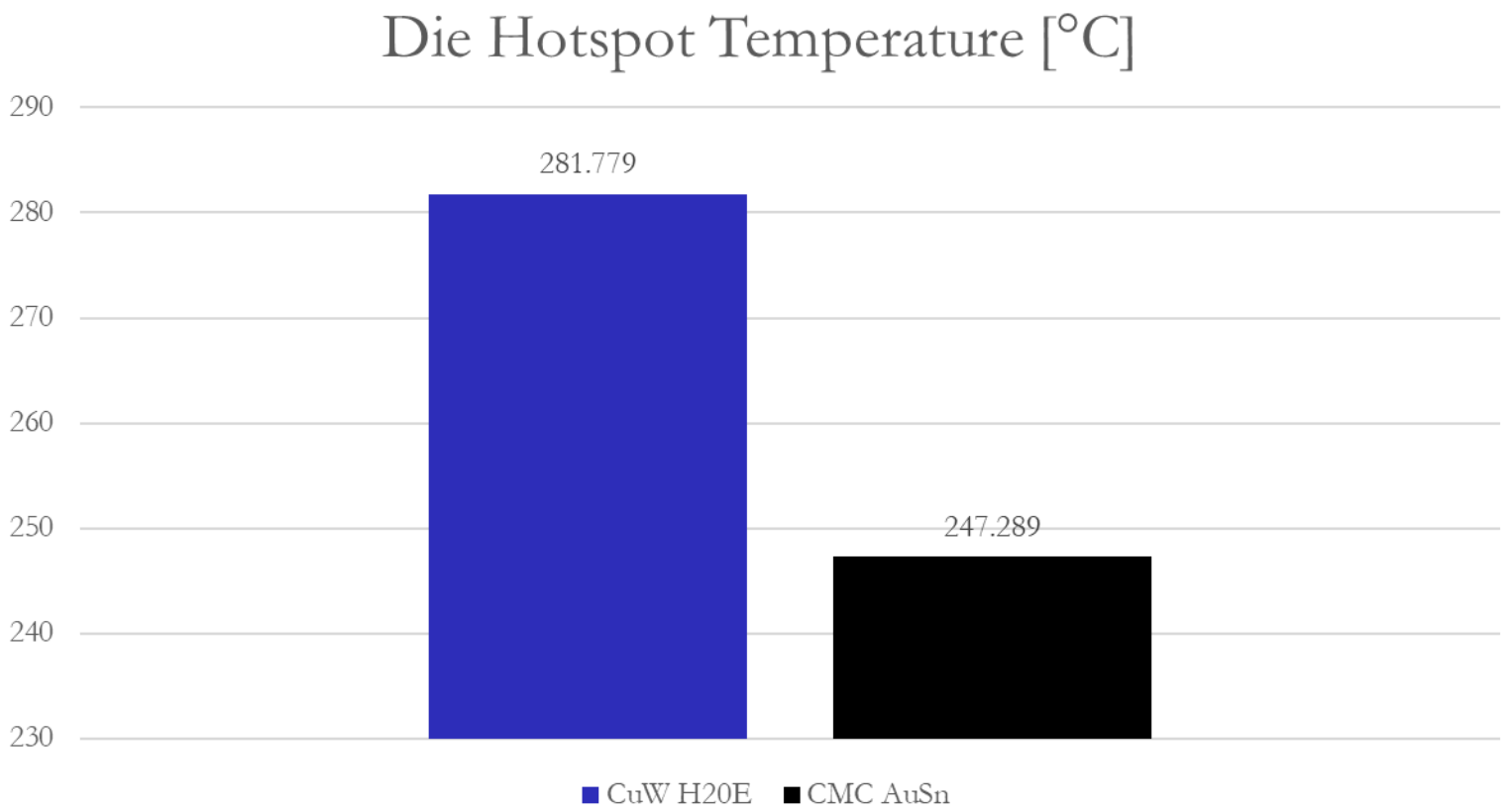
High Speed
High Power





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Summary

	H20E Epoxy	AuSn Solder
CuW base	281.8	257.3
CMC Base	272.9	247.3

Transistor temperatures for different combinations of base material and die attach material (all temperatures in degrees Celsius)

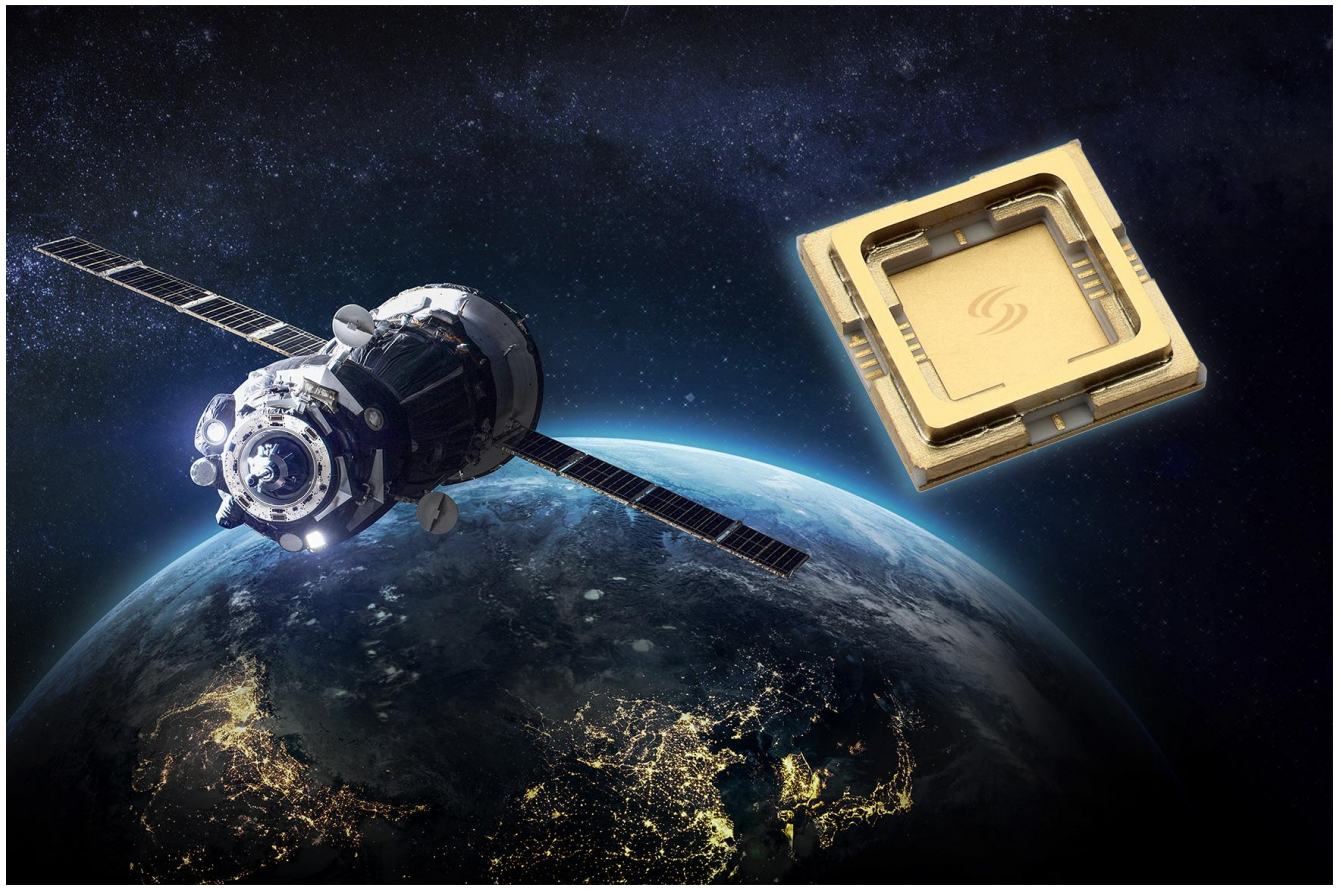
High Frequency
High Speed
High Power

Summary

- CMC base ~10 °C cooler than CuW Base
- Eutectic (AuSn) die attach ~25 °C cooler than EPO-TEK® H20E
- Comparing CMC with AuSn to CuW with H20E: Total temperature delta is 34.49 °C
- Validated empirical results previously provided by customers
- Provides StratEdge a foundation for future studies

Thank you

High Frequency
High Speed
High Power



Please contact me at
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if you have any additional questions.

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