



Challenges in Heterogonous Integration

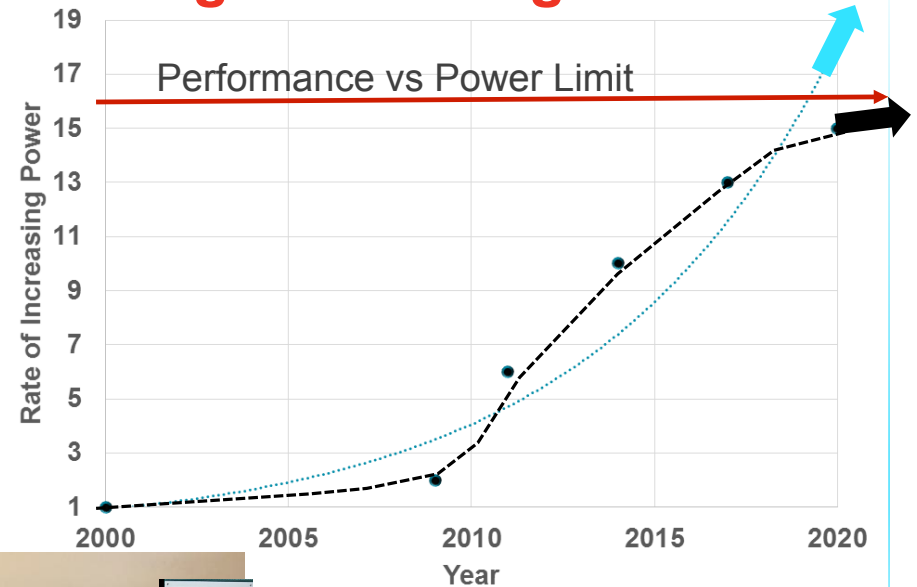
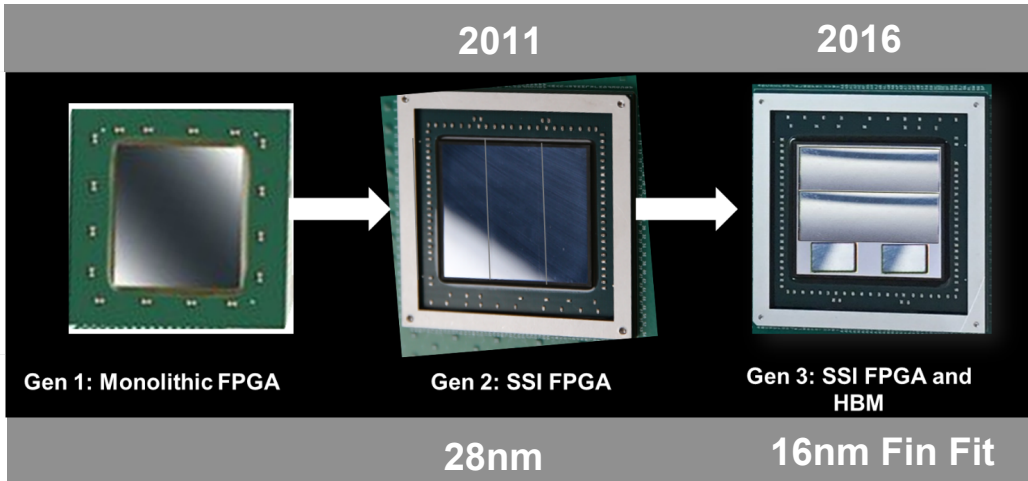
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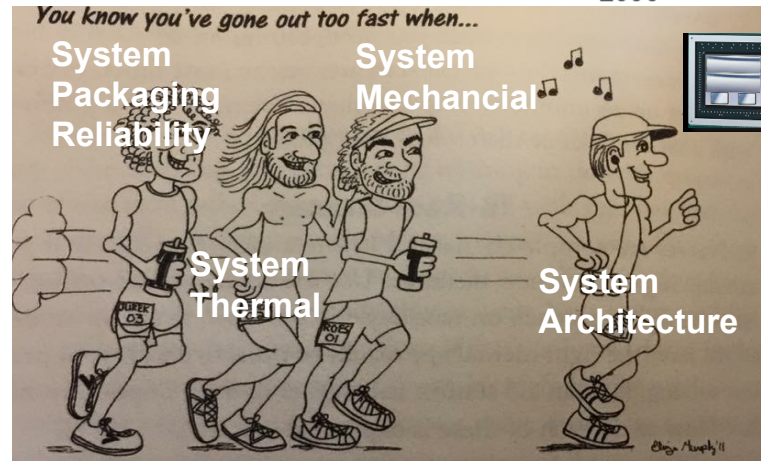
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Evolving of FPGA from Monolithic to Heterogeneous Integration



FPGA Packaging

FPGA Thermal Load



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Need of Heterogonous Integration vs Understanding Challenges

Conditions	Limits
Temperature	
• Operating (up to 1829 m (6000 ft))	5°C to 40°C
• Short-term ²	-5°C to 50°C
• Short-term with fan failure	-5°C to 40°C
Rates of Temperature Change	
• Operating	30°C/hr
Relative Humidity	
• Operating	5% to 85%
• Short-term ²	5% to 93%, but not to exceed 0.026 kg water/kg of dry air

Based on GR 63 Air condition failure scenario

Our Target Operation

Class ¹	Dry-Bulb Temperature ² , °C	Humidity Range, Noncondensing ³	Maximum Dew Point, °C	Maximum Elevation ⁴ , m	Maximum Rate of Change ⁵ , °C/h	Dry-Bulb Temperature, °C	RH, %	Maximum Dew Point, °C
Recommended (Suitable for all 4 classes; explore data center metrics in this paper for conditions outside this range.)								
A1 to A4	15 to 27	2.3°C DP to 10% RH and 17°C DP	17	3050	5 to 20	5 to 45	5 to 90	27
Allowable								
A1	15 to 32	20% to 10% RH	21	3050	5 to 20	5 to 45	5 to 90	27
A2	10 to 35	20% to 10% RH to 85% RH	24	3050	5 to 45	5 to 80	5 to 80	27
B	5 to 15	10% to 10% RH	25	3050	N/A	5 to 45	5 to 90	29
C	5 to 40	10% to 10% RH	25	3050	N/A	5 to 45	5 to 90	29

It is not 85C it is lower

Handwritten notes: "Metal case", "what is max temp?", "what is min temp?", "what is RH?", "what is the cooling system?", "Torch Power", "Recommended Recommended ambient low 12°C max 6 avoid 45°C", "windshield", "45-60°C outside ambient", "45-50°C inside ambient", "Solar load".

For Dual Shelf We need to maintain 55C

Understanding System impact on device

Enclosure (shaded solid)

Motherboard which has FPGA

Enclosure (wireframe)

GR487:

- 40C to 46C without solar load
- Solar load is 753 W/m² in 3 adjacent faces
- In general the max ambient is quoted with solar load in range of 55C to 65C

Understanding surrounding Environment

Duty Cycle/Year	Ambient Temp ⁺	Hot Sink	Junction temperature
7.5%	4.4C(40F)	25C	47C
60%	28C (82F)	48C	70C
25%	47C(117F)	67C	89C
7.5%	58C(136F)	78C	100C

+ with Solar

The average fraction of time spent in various temperature bands:
 frigid (below 18°F), freezing (18°F to 32°F),
 cold (32°F to 50°F), cool (50°F to 65°F), comfortable (65°F to 75°F),
 warm (75°F to 85°F), hot (85°F to 100°F) and sweltering (above 100°F)

<https://weatherspark.com/>

Analyzing the Component

Heat sink Hotspot from FPGA (in the range of 74C to 80C)

Partial Holistic View of Challenges

- Operating environment
 - Operating temperature
 - Application load
 - Qual Thermal /Power/Mechanical (System vs Package)
- Thermal management device
 - Mechanical attachment
 - Applying pressure
 - Thermal interface levels 1vs 1.5 vs 2
- Package enablement
 - Assembly on system
 - Coplanarity and Warpage
 - Joule heating/Electromigration
 - Qual Thermal /Power/Mechanical (Package vs System)
- Silicon Integration
 - Assembly on package
 - Joule heating/Electromigration
 - Performance

