HOPE

High Density Power Electronics for FC- and ICE-Hybrid Electric Vehicle Powertrains

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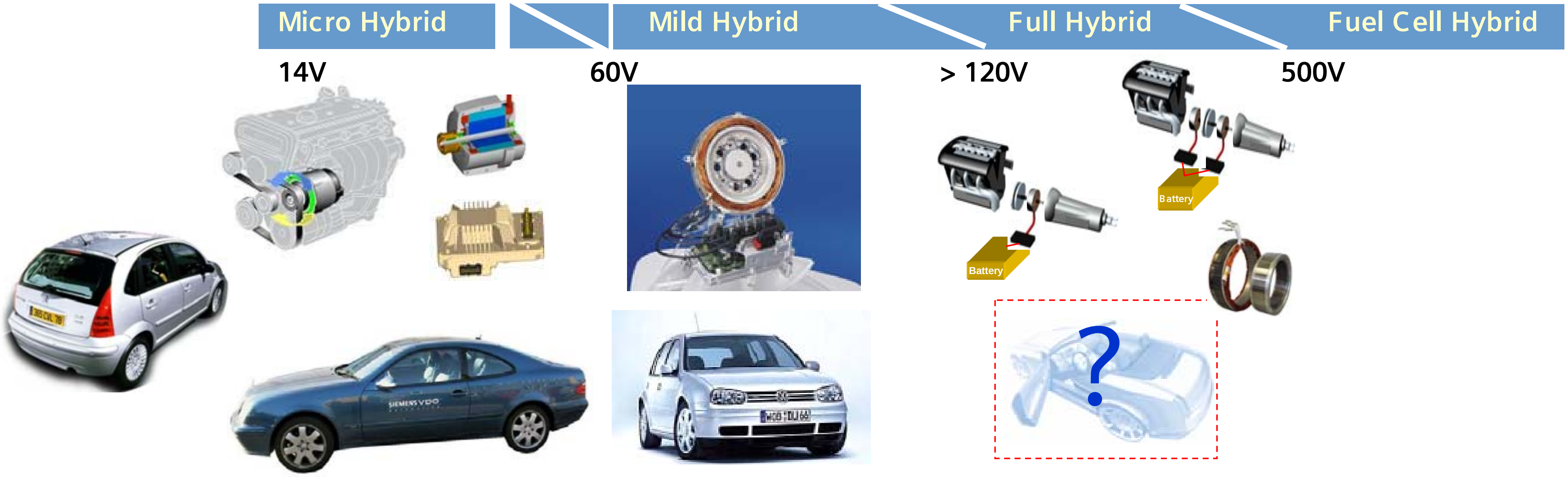
Consortium Members

Co-ordinator: Siemens Corporate Technology

OEM	**Supplier**	**Research Institutes**
DaimlerChrysler (D)	**Bosch (D)**	**Fraunhofer IISB (D)**
Renault (F)	**SiemensVDO (D)**	**INRETS (F)**
Volkswagen (D)	**Magna Steyr (A)**	**University of Technology Belfort-Montbéliard (F)**
	Valeo (F)	**Swiss Federal Institute of Technology Zurich (CH)**
		Warsaw University of Technology (PL)

FC- and ICE- Hybrid Electric Vehicles: Classification



Micro Hybrid | Mild Hybrid | Full Hybrid | Fuel Cell Hybrid

14V | 60V | > 120V | 500V

Stop-Start System

Implemented Functions:
- Stop-Start-Automatic
- Cold start with SSG
- Fast start <400ms
- Battery-Management
- SOC control
- Intelligent Belt Tensioner
- 6 % improved F.E.

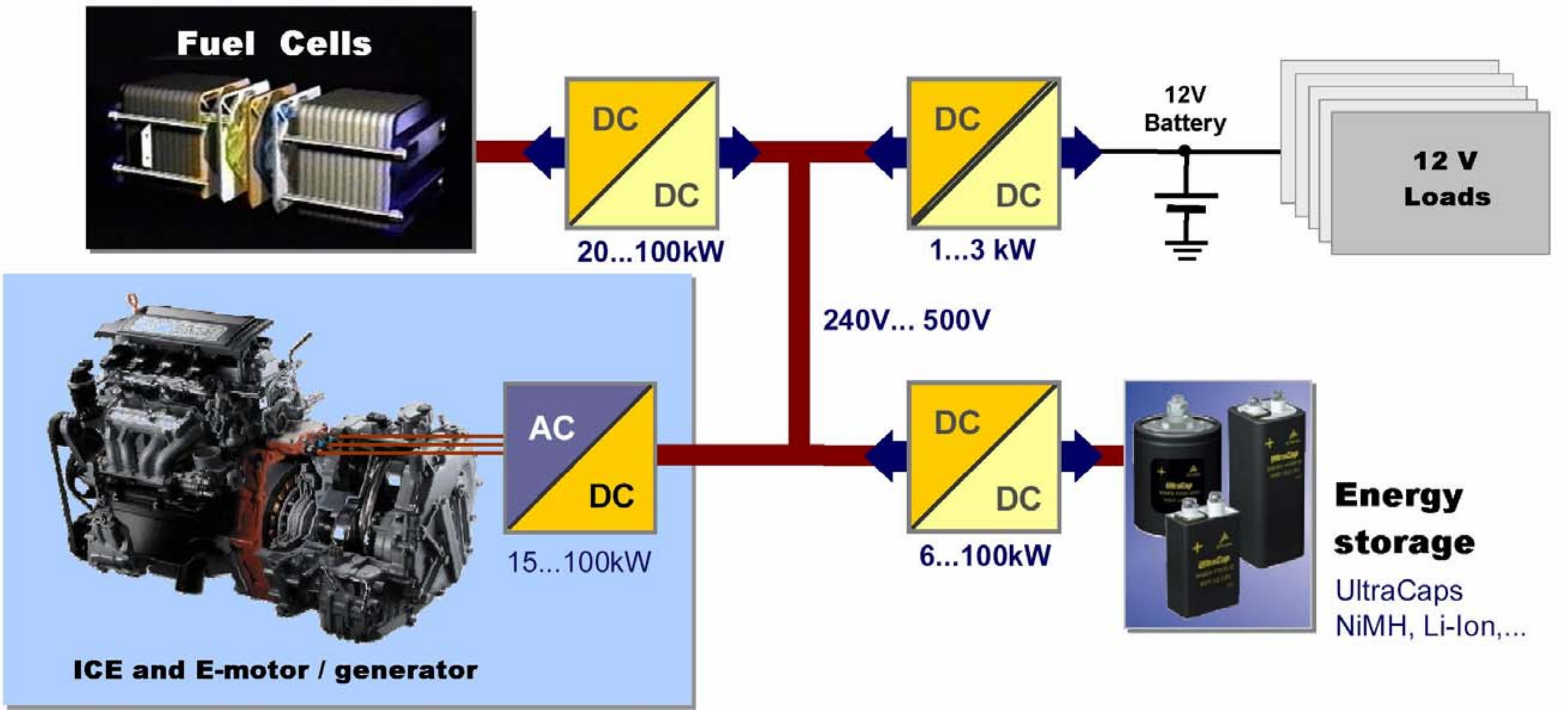
Mild Hybrid System

Implemented Functions:
- Stop-Start Automatic
- Fast start <300ms,
- Cold start <800 ms
- Coasting + regen. braking (basic)
- Battery and Capacitor Charge
- Electric Boost and Launch Assist
- 15 – 18% improved F.E.

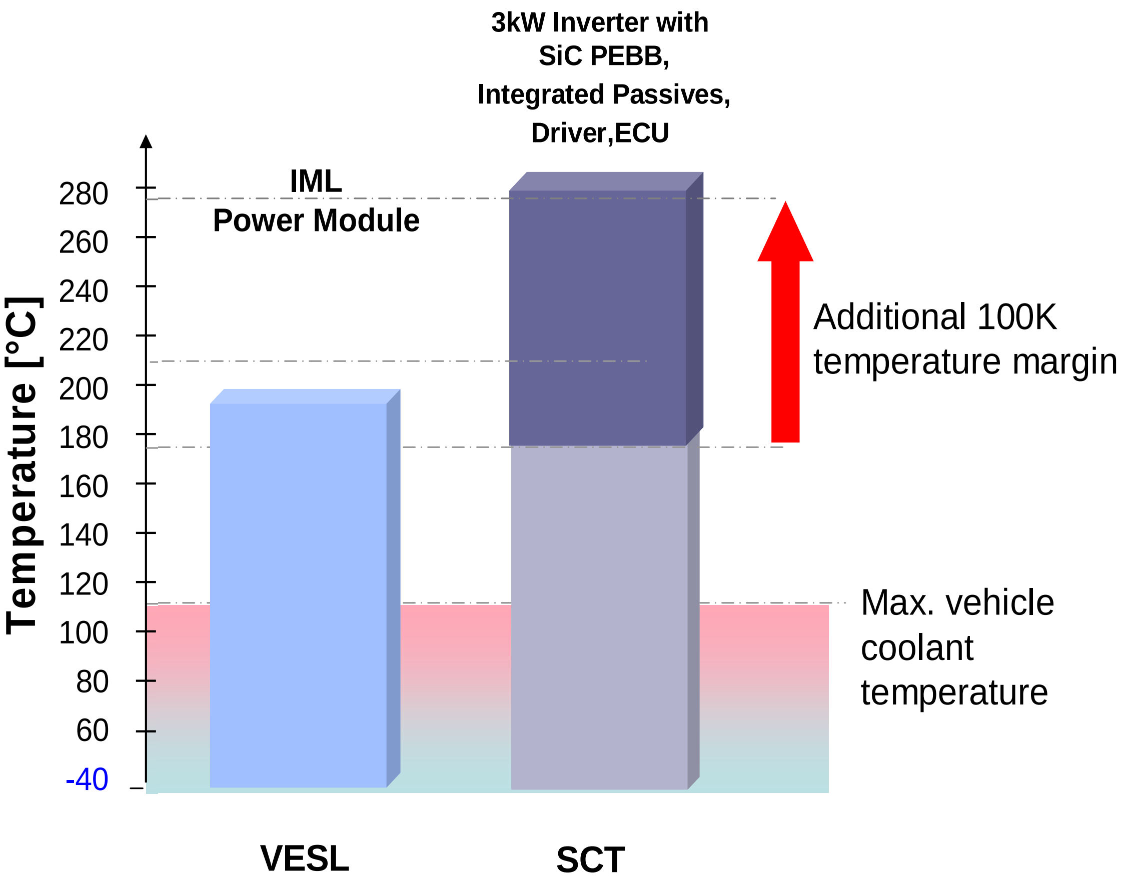
Full Hybrid System

Target Functions:
- Pure electric drive
- Drivability
- Efficiency
  - Combustion engine
  - E–Motor(s)
  - Combination
- Regenerative Braking (enhanced)

Block Diagram for FC- and ICE-HEV Powertrain



The two Concepts for New Power Electronics Modules in HOPE



Overview HOPE: Main Challenges

1. Performance

- High-temperature power electronics

2. Low Cost

- Use inserted molded leadframe concept without ceramic substrate insulation
- Introduce standardized power electronics building blocks

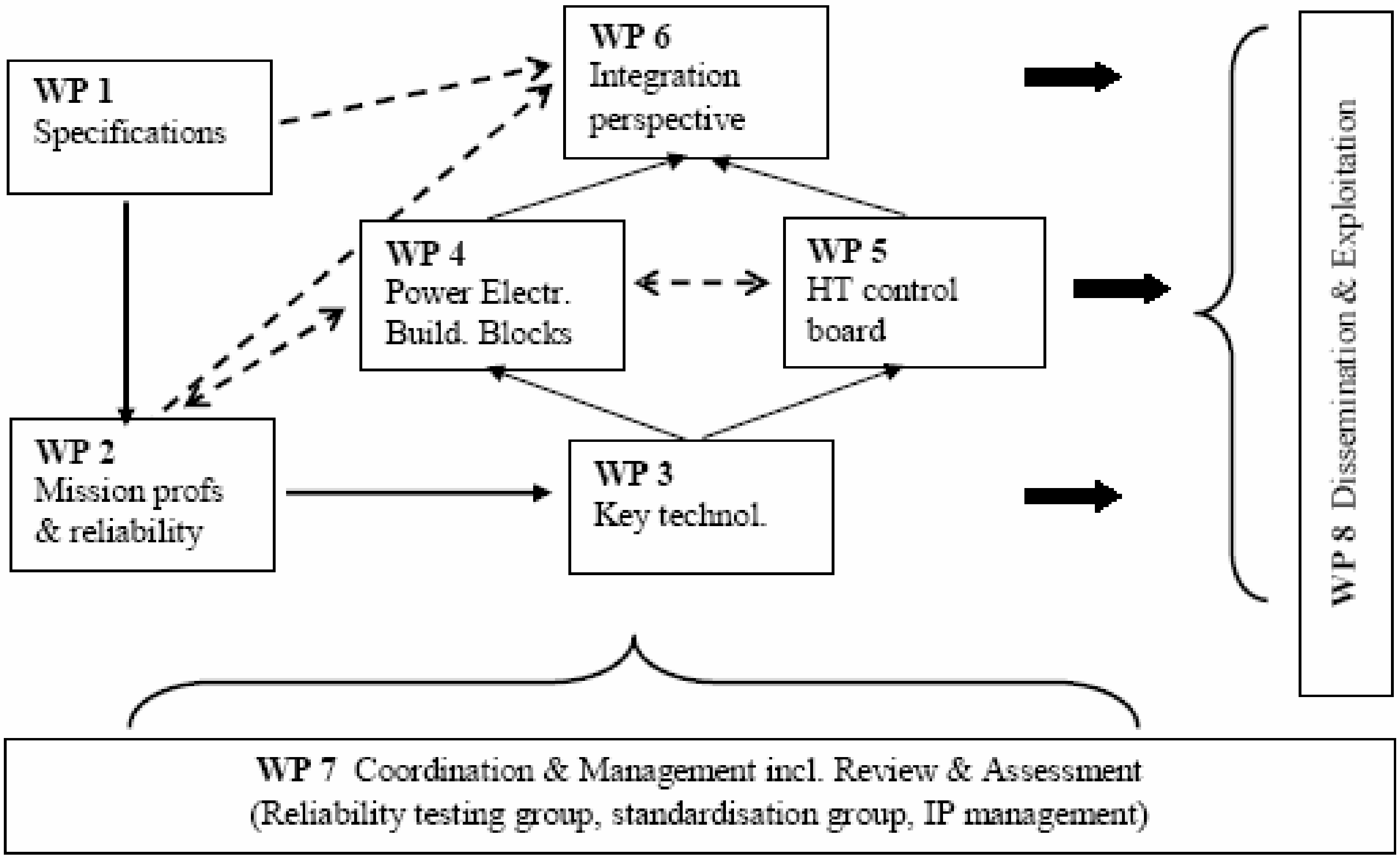
3. Reliability

- Failue rate increases with temperature

Comparison of the two NEW Concepts

	PMM (VESL)	**SiC- PEBB (SCT)**
New approach	**Leadframe**	**SiC**
Savings in contrast to state of the art	Ceramic-free insulator, integrated inter-connection with drive	No cooling circuit
Main research goals	Optimization of a set of materials (plastic, metals, solders) and thermal flow	Very high temperature operation
Main challenges	Reliability	Packaging, driver electronics, heat dissipation

HOPE: Interdependencies between the Workpackages



HOPE: List of Work Packages and Amount of Men Month

Work-package No[1]	Workpackage title	Lead contract. No[2]	Person-months[3]	Start month[4]	End month[5]	Deliverable No[6]
1	Common specifications and standardisation evaluation	7	6	1	3	D1.1, D1.2
2	Mission profiles and reliability assessment	5	57	1	36	D2.1 – D2.7
3	Key technologies for high power density electronics	4	131	1	36	D3.1 – D3.8
4	Power electronic building blocks and inverters	1	44,5	6	36	D4.1 – D4.5
5	High temperature control board	9	15	1	36	D5.1, D5.2
6	Perspectives of inverter integration into powertrain	6	41	1	36	D6.1 – D6.4
7	Coordination and Management	1	8,3	1	36	D7.1 – D7.8
8	Dissemination and exploitation	1	10,25	1	36	D8.1 – D8.3
	TOTAL		**313**			

HOPE: Main Innovations / 1

1. Industrial standards for PEBB
    - Footprint
    - Height
    - Terminations
    - Interfaces to drivers and control electronics
    - Thermal interfaces
    - EMI properties
    - Materials (according to UL standards, etc.)

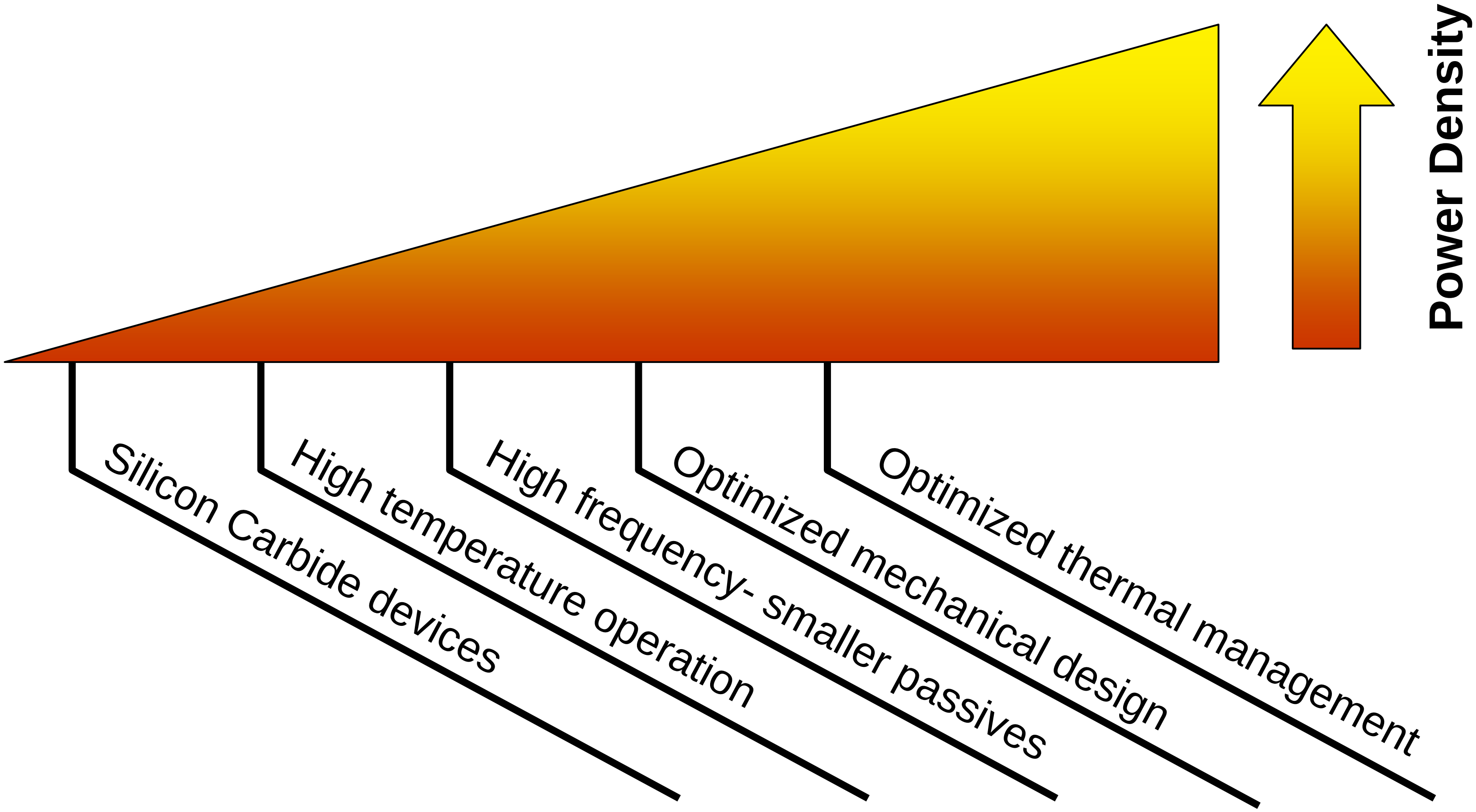
2. Subsystems level
    - topology for SiC-inverter
    - driver circuit for SiC
    - New cooling concepts e.g double-sided cooling
    - Mechatronic approach for inverter
    - Improved commutation cells for very fast switching

HOPE: Main Innovations / 2

3. Components and materials
   - RF and HT sensors
   - New materials,
   - New technologies for die attach and other joining e.g. nanoscale low temperature joining (LTJ)
   - New assembling technologies e.g. insert molded leadframe technology

4. Test methodologies
   - Reliability tests
   - Mission profile tests
   - Lifetime prognosis

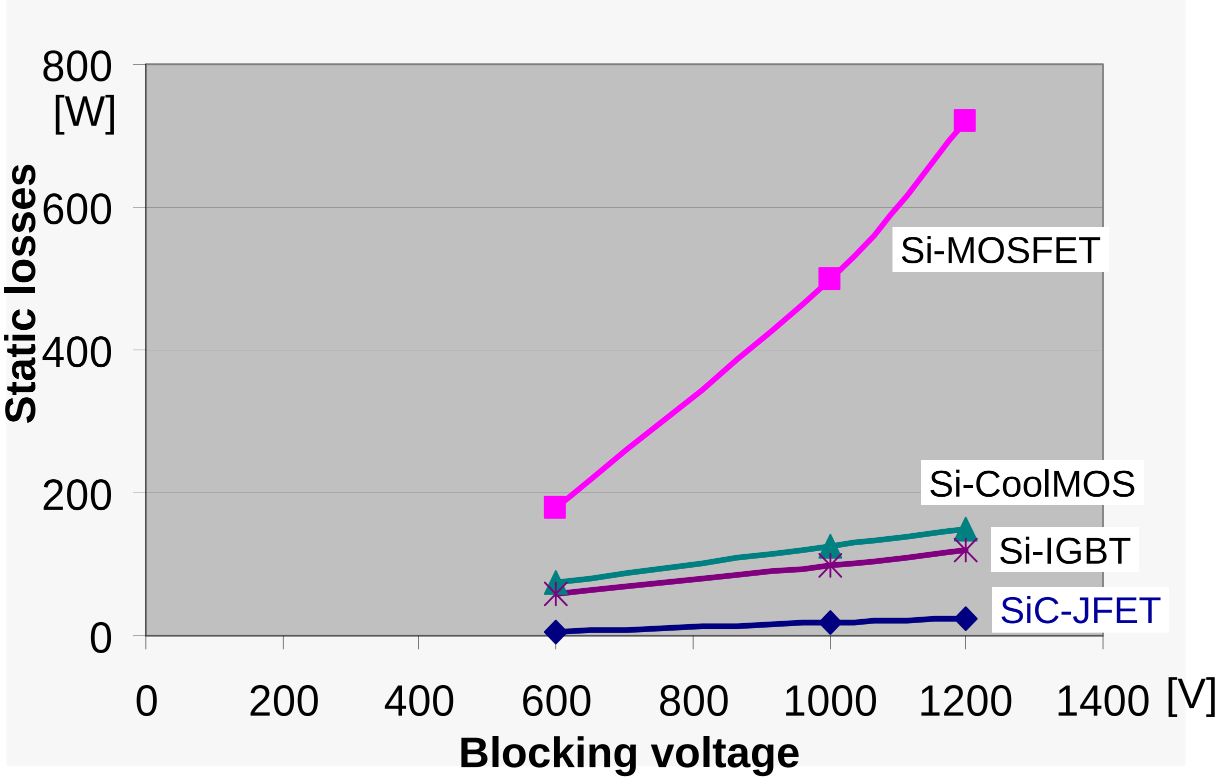
Expected Increase in Power Density by a Factor of 4 by using SiC JFETs



Power Density

- Silicon Carbide devices
- High temperature operation
- High frequency- smaller passives
- Optimized mechanical design
- Optimized thermal management

SiC-Transistors have in contrast to Si-Transistors less losses (1 cm^2, 50 A)

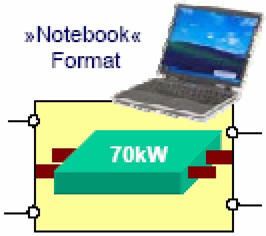


Competence in Silicon Carbide Electronics

xxx

SiC power devices in electric vehicles

Lower losses for a given power rating
⇩
Higher case temperatures possible



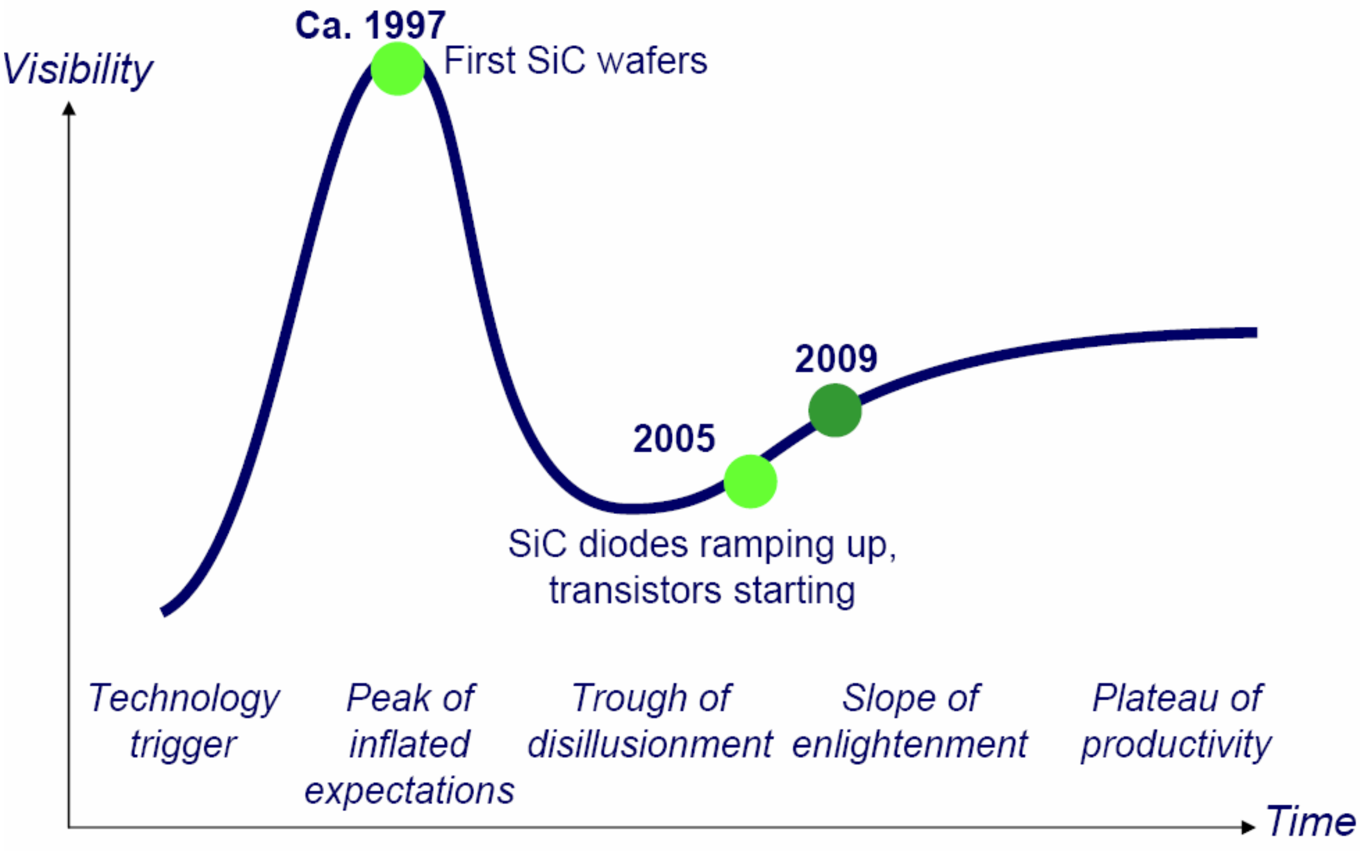
30 W/cm^3

Higher operating temperatures possible
⇩
Higher power density achievable

Robust components (e.g. radiation hard)
⇩
Reliable operation also under harsh environmental conditions

SiCED
A Siemens Company

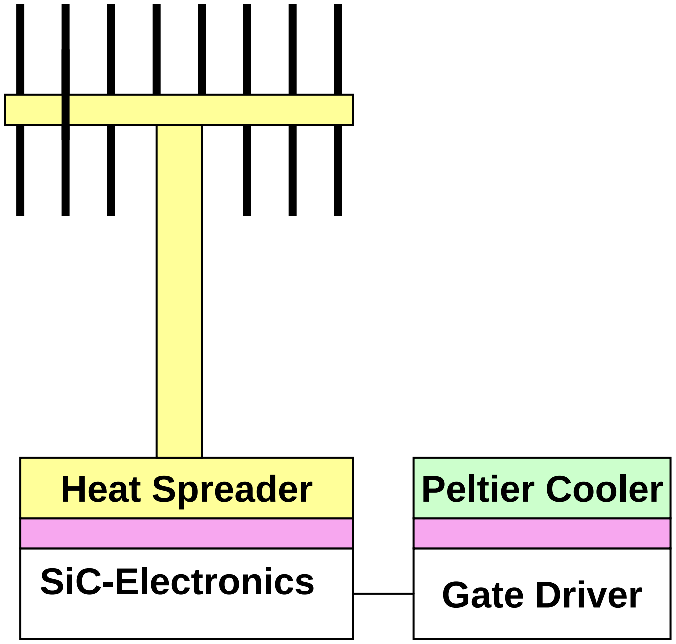
SiC-History



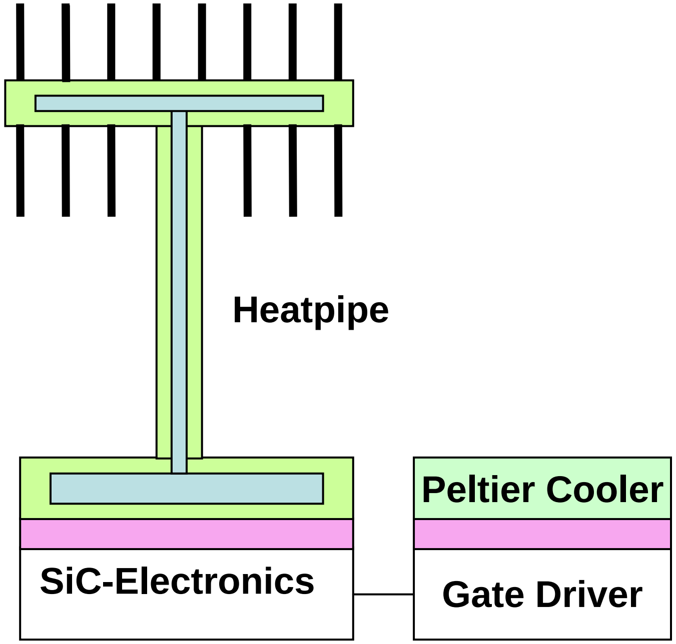
Source [3]

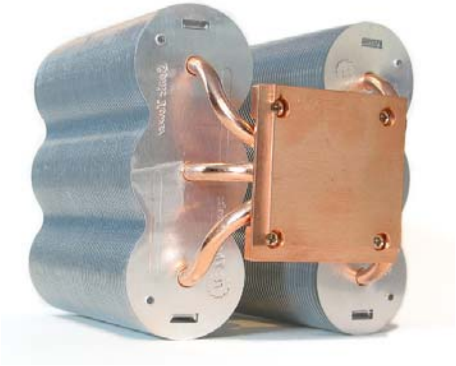
Passive Cooling Using the High Temperature Difference between SiC Junction and Ambient

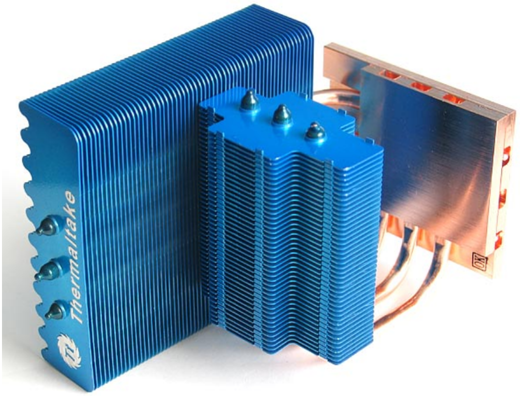
Natural Convection

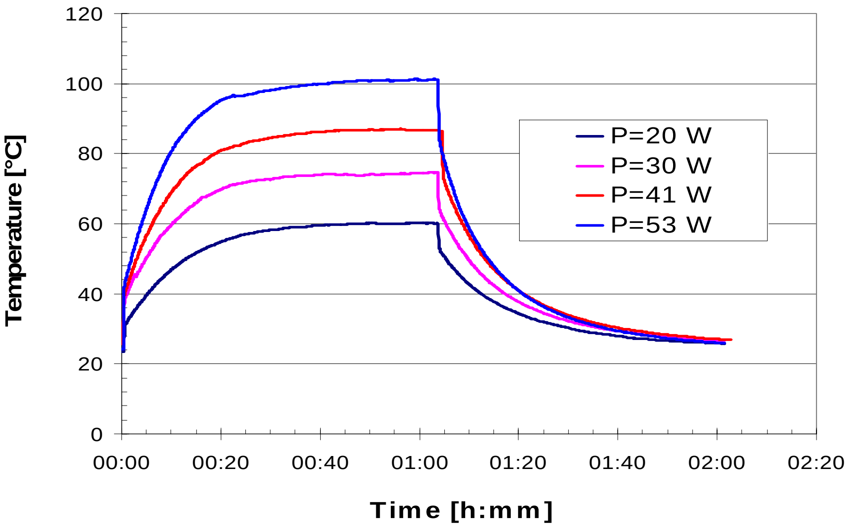


Heat Pipe Cooling

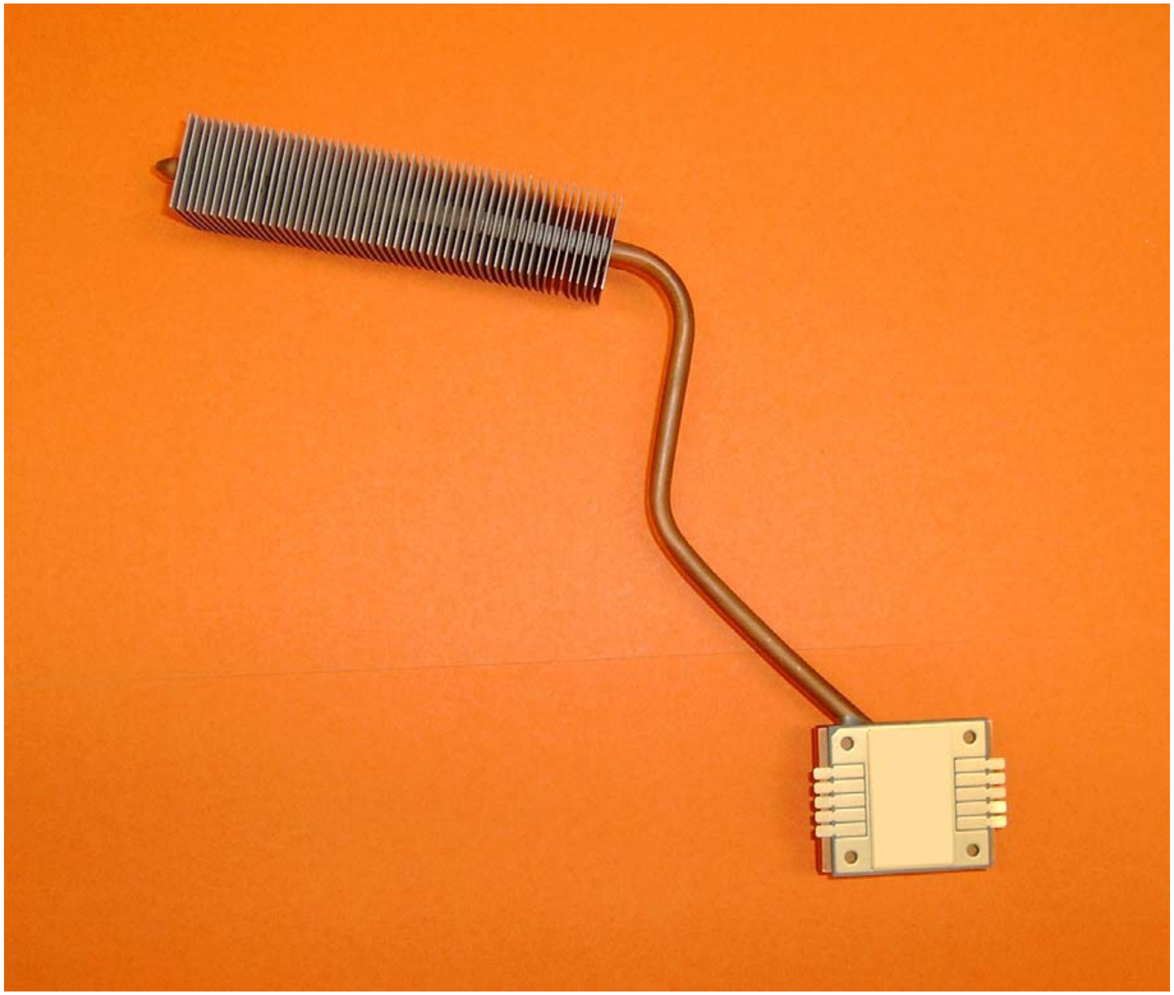





Thermaltake


120
100
80
60
40
20
0
Temperature [°C]
00:00
00:20
00:40
01:00
01:20
01:40
02:00
02:20
Time [h:mm]
P=20 W
P=30 W
P=41 W
P=53 W

Heatpipe



Status

- Deliverable D1.1 OEM specifications
- Deliverable D2.1 defines mission profiles
- Deliverable D3.1 defines PEBB / performance

- All devices and components are available and ready to build power electronics building blocks

Summary

HOPE wants to find out

- 1. Physical limits for high temp operation using SiC devices as an example
- 2. Find a cost effective solution using Valeos approach