# Embedded Die Power Modules penetrating the Automotive Sector

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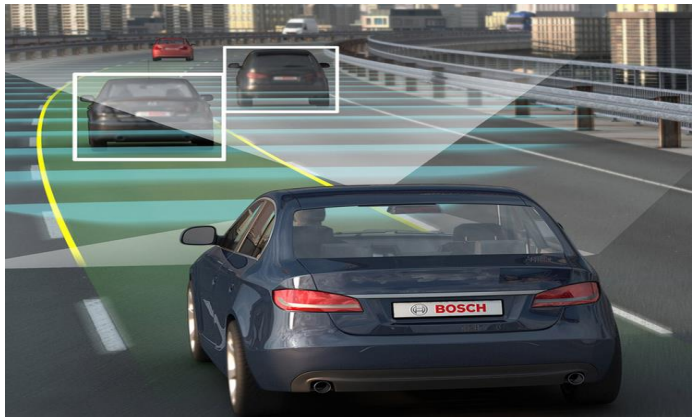
# Content

- ATV packaging evolution and requirement
- Embedded Technology (a-EASI*) & track record
- Summary

*advanced Embedded Active System Integration

# ATV Market Trend

## Autonomous Driving - ADAS




courtesy by Bosch

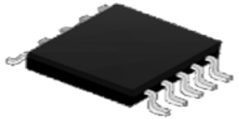
- Sensors & Computing
- Comfort & Infotainment

## Low $CO_2$ emission

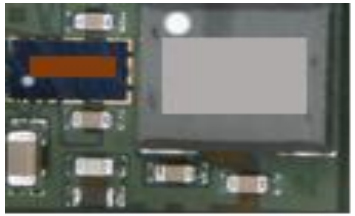

- Electric Powertrain
- Cleaner combustion engine

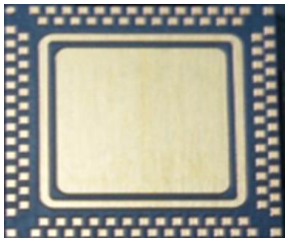
# ATV Packaging Evolution

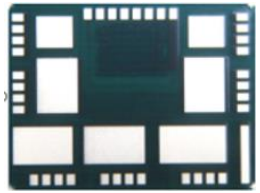
- Well known, simple and trusted Technologies
- PCBA assembled Electronics of discrete devices
- High Reliability Lead Frame Packages

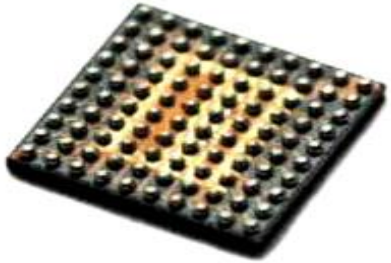


- New Packaging Technologies
- SiP - System in Package
- High Reliability Packages



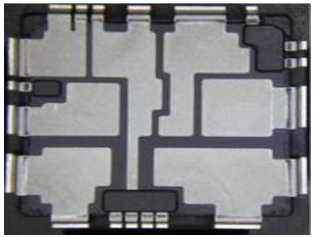


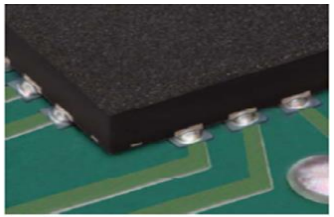




# ATV Requirements add Cost

- High reliability in Packages and on Board reliability
  - Au, Cu, Al Bond Wire, Cu Clip
  - Rough Lead Frame
  - Mold Compound with Adhesion Promoters
  - Low CTE laminate Substrates
  - No Contamination – Cleanliness - Clean Room
  - Full traceable Zero Defect Production
    - Dedicated Automated Lines
    - Dedicated Personnel
    - More Inspection
  - AOI - optical vs. AXI x-ray inspectable solder joints
  - Creepage Distance
- High investment needs adequate volumes
- Special materials need to become standard

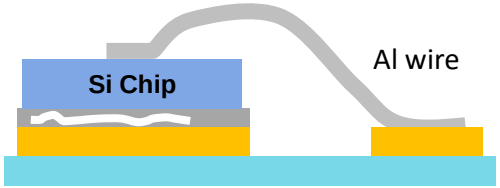


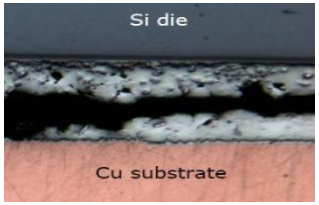


Visual Image (wettable)

# Embedded Power Die - Reliability

Power Electronic Packages

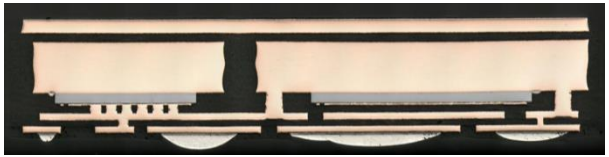


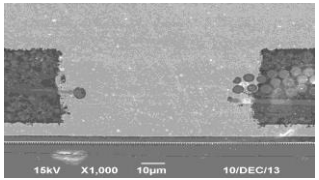




Al wire
Crack propagates through Al wire matrix
Increases electrical/thermal resistance

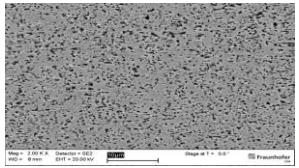
Soft Solder
Crack formation in solder volume
Increases thermal / electrical resistance

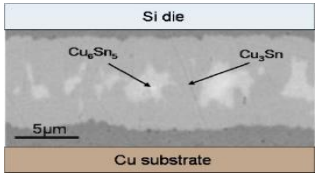
a-EASI Power Packages





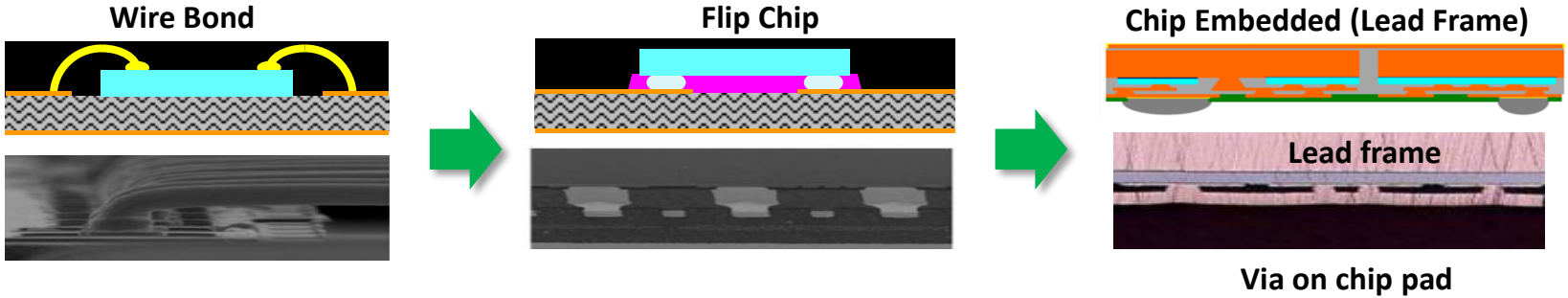

µ-via
Copper filled micro vias on Cu die pad
No crack expected





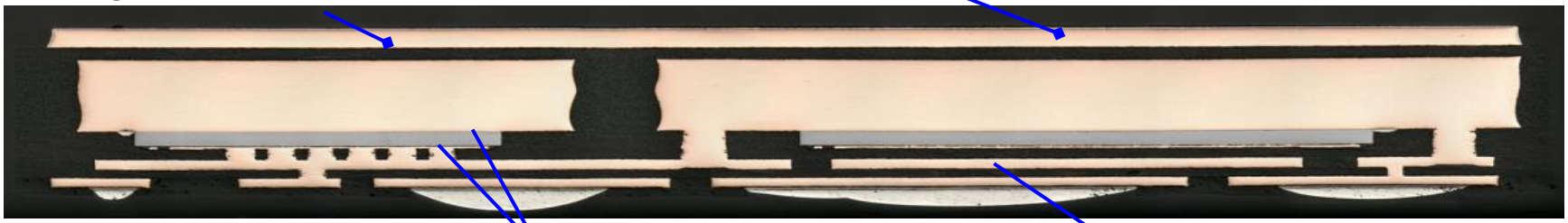

TLPB / Ag Sintering
High melting point > 400°C
Stable against thermal stress

# Interconnection Evolution




Good Thermal Dissipation
EMI Shielding

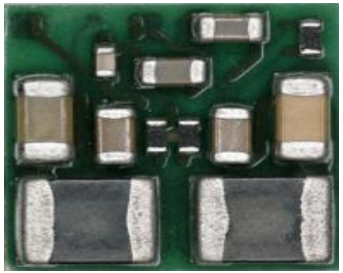
SMD on Top of package

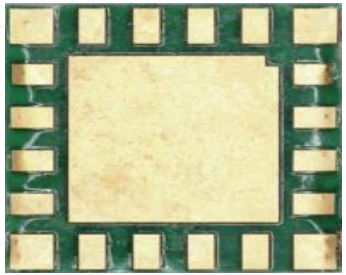


Extreme Low resistance and inductance electrical contact

Multiple RDL Layer

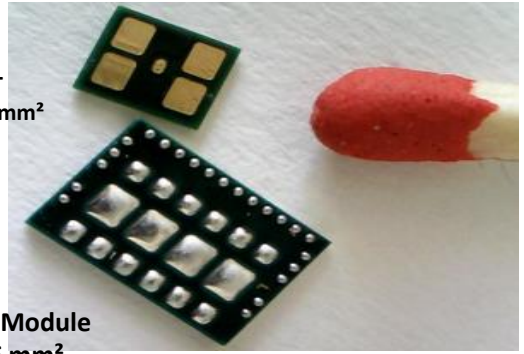
# Power Device & Module by Chip Embedded Technology



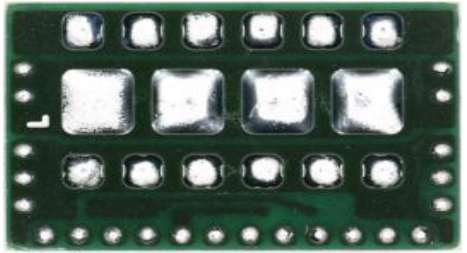


**Package Size: 5 x 5 x 0.57 mm** (exclude passives height)
**1 Micro Power Management Chip**
**Passives: 12pc (0806 x 2, 0603 x 2, 0402 x 4, 0201 x 4)**
**RDL: 2+1 Layer**

**MOSFET**
**3.4x3.0 mm²**



**DC/DC Module**
**4.5x6.6 mm²**

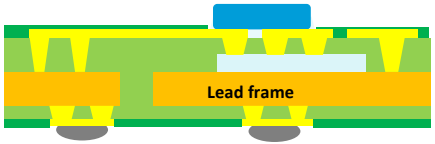
**Package Size: 6.65 x 4.55 x 0.8 mm**
**2 power MOSFET + 1 Driver**
**RDL: 2+1 Layer**

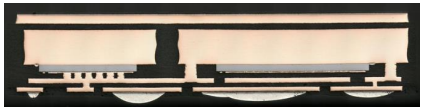
# a-EASI Package Roadmap

**P1**

**Production since 2014**

- Excellent Electrical & Thermal performance
- HVM Production proven

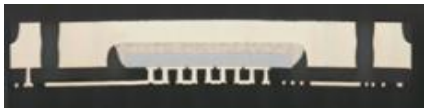


**P2**

**Production since 2020**

- Thermal Enhance (Exposed pad)
- Thinner Package
- Support various footprint (BGA, LGA, QFN)



**P3**

**Production since 2021**

- Improve design flexibility for vertical current device.
- Highly Integration – Smaller form factor

**P4**

**Production plan 2023**

- Wafer level size & foot print
- Extreme simplify the interconnection for power discrete

# ASEKH a-EASI Package Milestones

Consumer

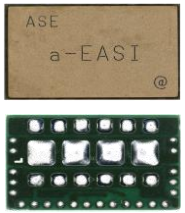
Solar Energy

ATV

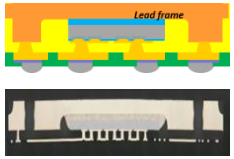
Data Center

- Start HVM in P1

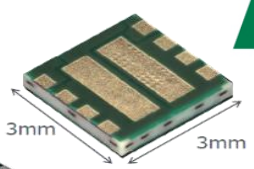
Industrial




- P2 Development

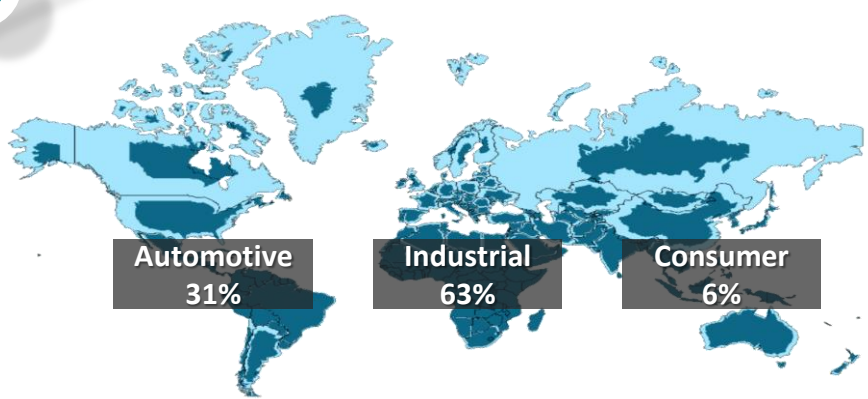



- P3 Development



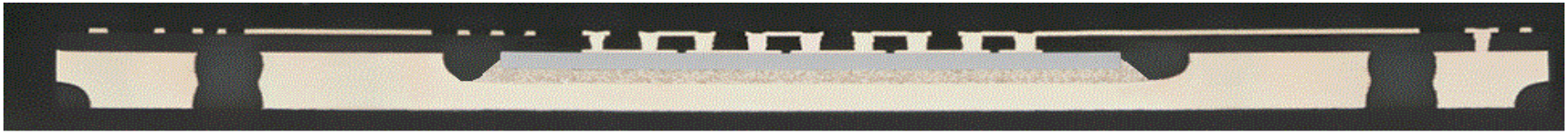

>101Mu

- P4 Development




2013 | 2014 | 2015 | 2016 | 2017 | 2018-19 | 2020

# a-EASI P2 – Process Flow



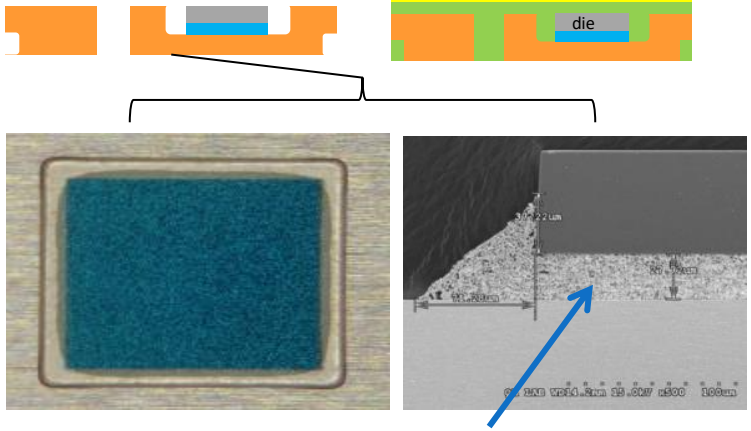
Die attach

Lamination

Laser drill

Plating &

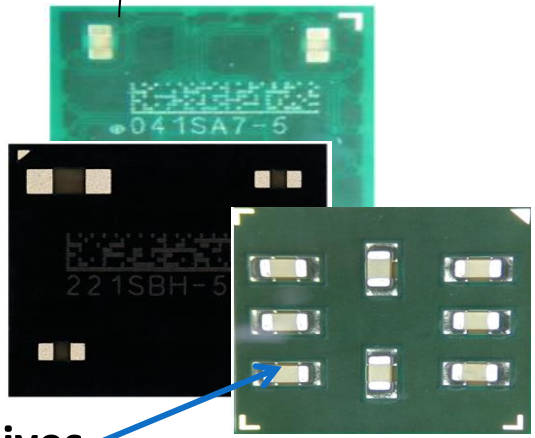
S/M, Marking,



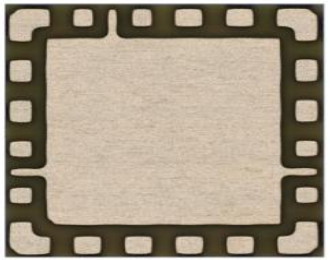





Ag Sintering
(75W/mk-92W/mk)

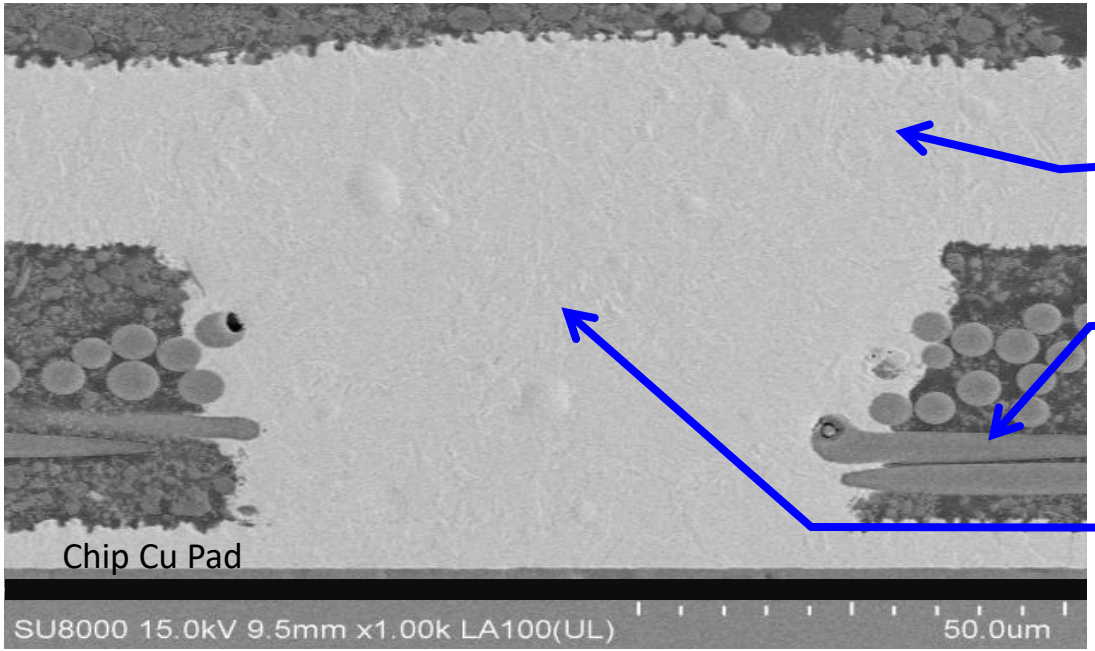


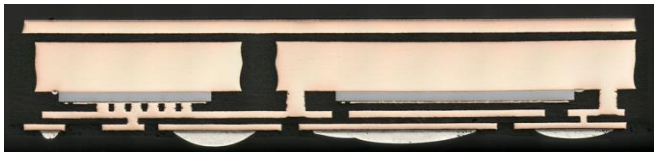

Passives



Bottom View

# a-EASI Interconnection Highlight



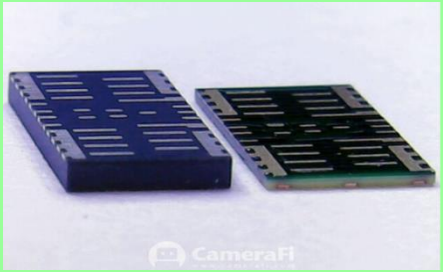



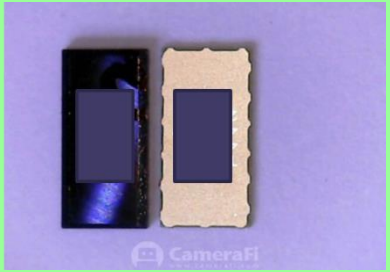
- Thick Cu RDL (32 um or more). Minimize turn on resistance.
- Prepreg material provide >2.5KV breakdown voltage
- Tg = 200°C → 250°C
- 70um via (~ 1 mil Cu wire x 9)
- Cu to Cu interface. Minimize reliability risk in high current density condition

# a-EASI performance demonstration

## Thermal (> 80% improve)

- PMIC

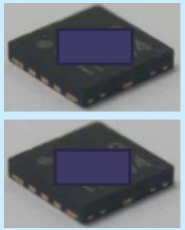




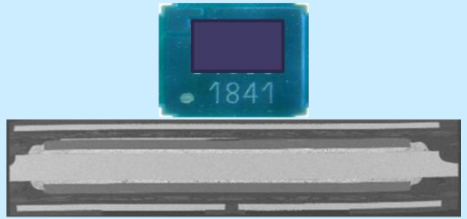
## Size ( 50% reduction)

- Battery Charger Protection

2 DFN for 2 MOSFET

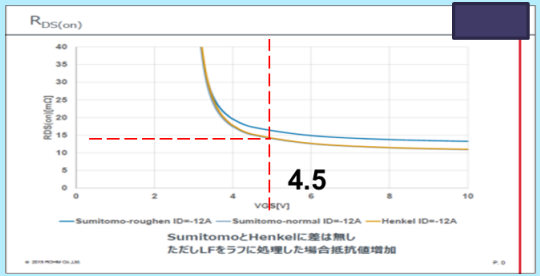


a-EASI P3 solution




## Electrical (> 82% improve)

- $R_{DS(on)}$ is 82% better than DFN*2




| Package | $R_{DS(on)}$ @ Vgs 4.5V |
|---|---|
| DFN*2 | 84 mΩ |
| a-EASI | 15 mΩ |

## Reliability (ATV Grade 0)

- Brushless motor driver (PKG size 14.8x11.9)

| AEC-Q Reliability test | Active TC dT 100°K | H3TRB 85/85 | HTGB 150°C | TC -55/150°C | Technology test | BLR -40/125°C | Electro-migration |
|---|---|---|---|---|---|---|---|
| [redacted] | End-of-life | 1000h | 1000h | 2000 | [redacted] | 2000TC | 150h, 150°C, 145A |
| Motivation | AEC-Q101 delta | | | Large pkg | Motivation | Leadless package | High Current |
| Status 12/2018 Electrical Test | Setup issues | PASS Low drift | 500h ok Low drift | 1000TC ok 2000TC ok | Status 12/2018 | PASS | PASS (w/o statistics) |
| Phys. Analysis | | - | - | 1500 ong. | Phys. Analysis | Page 5 | Page 3-4 |

# a-EASI Products and Projects

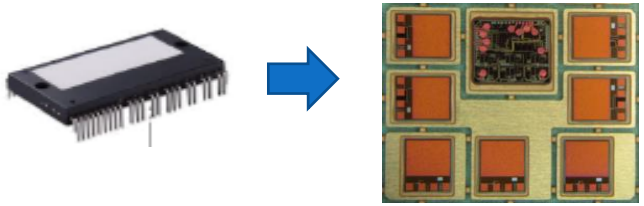
- EV: Low weight, high power efficiency for driven distance

  48V DCDC converter, SiC, IGBT(plan)

- Industry: better efficiency, PCB size down

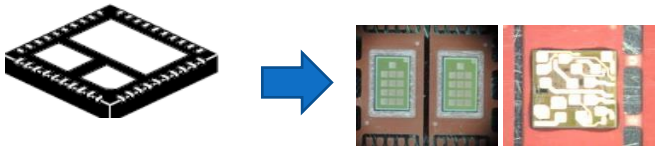
  3-phase full bridge circuit, Power management module

  GaN driver, lightening



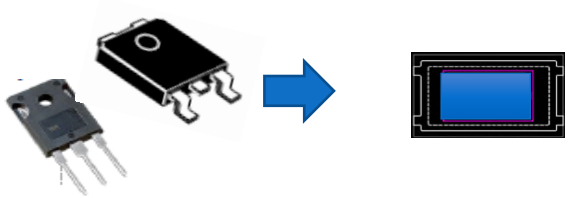
- Data center: Low power loss, integration of passives, lead free

  half bridge + Driver (DrMOS)

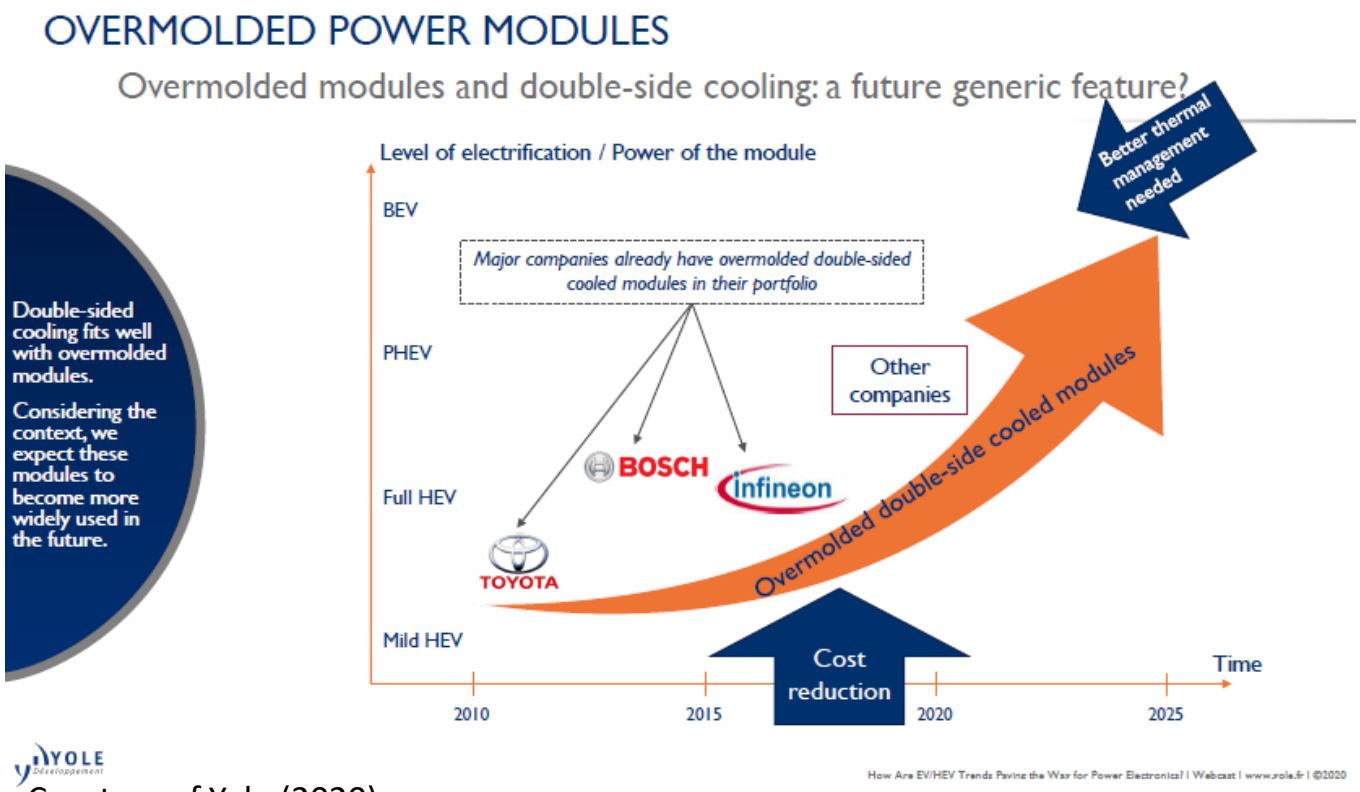


- Discrete: Low Pkg inductance, Rdson & high thermal dissipation

  MOSFET, SiC, GaN discrete



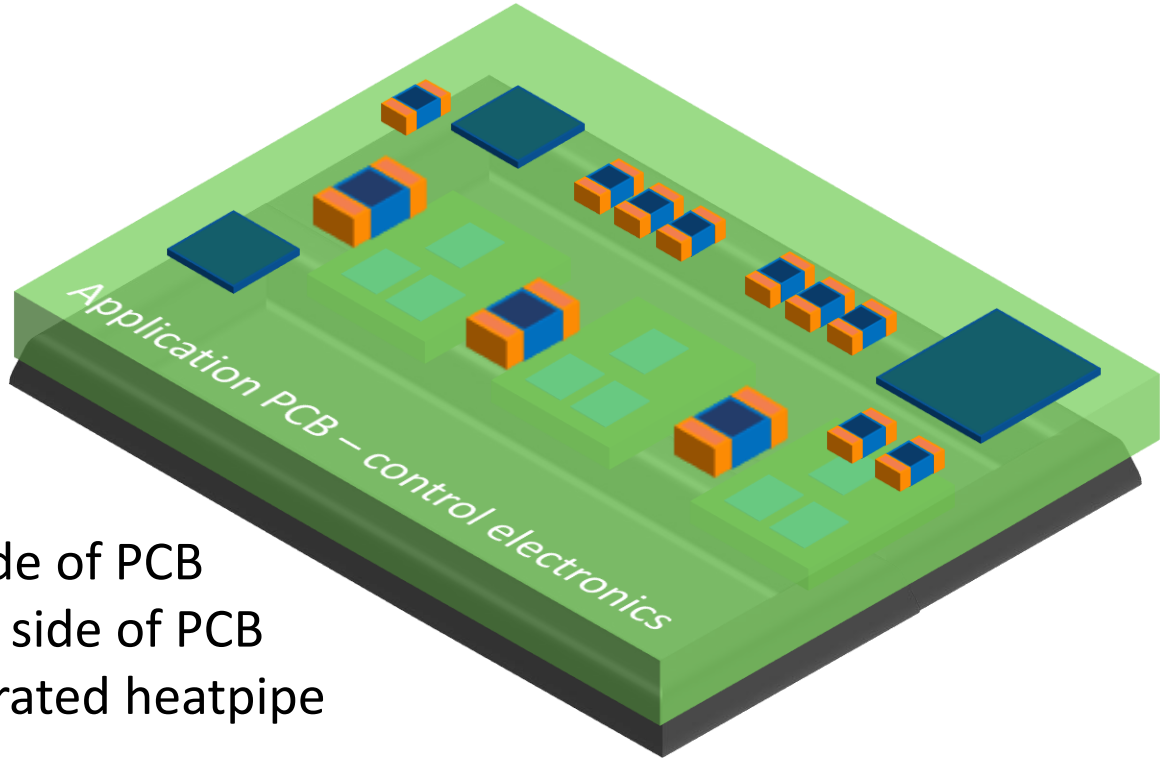
# Expected Market Trend




Courtesy of Yole (2020)

# Modularization with a-EASI IC embedding

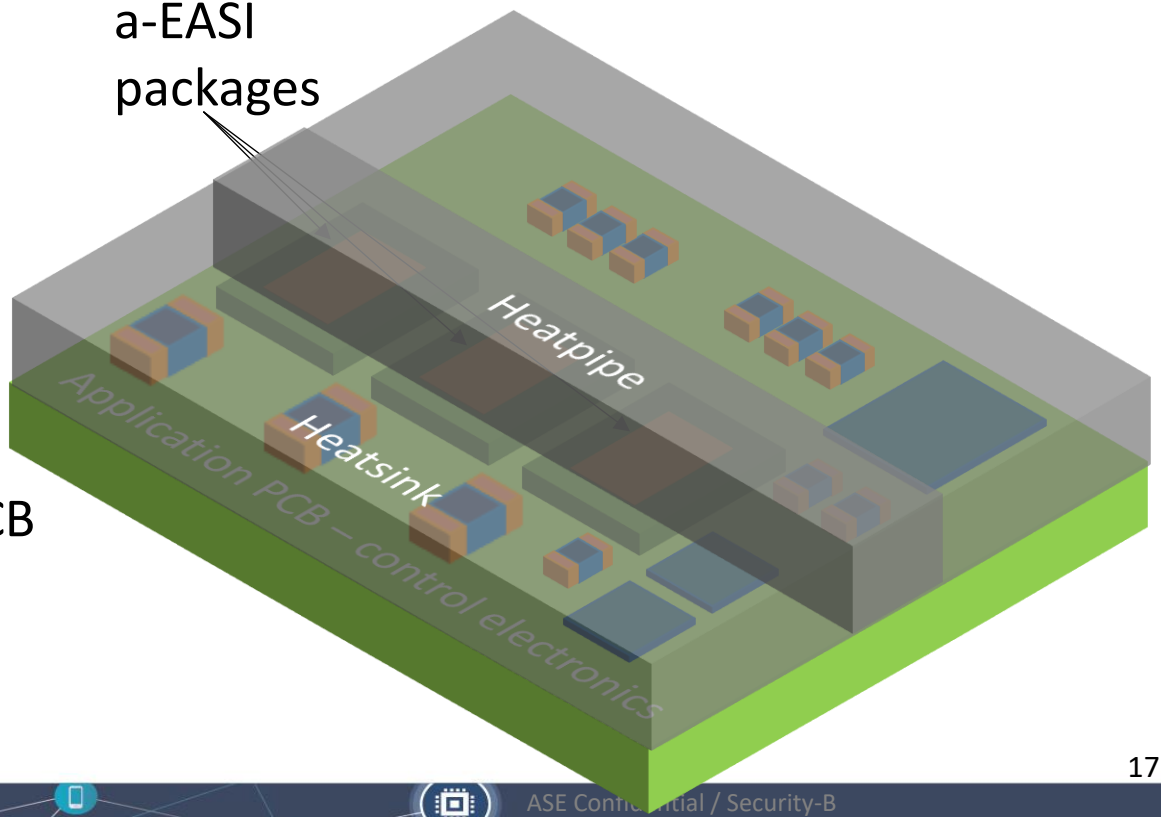
**Integration suggestion #1:**
**modularized approach**
**a-EASI half bridge packages**
**(2 MOSFETs in each)**




- Dual side PCB assembly
  - Control+driver top side of PCB
  - Power stages bottom side of PCB
- Heat sink cover with integrated heatpipe
- 10kW to 20kW

# Modularization with a-EASI IC embedding

**Integration suggestion #2:**
**modularized approach**
**a-EASI half bridge packages**
**(2 MOSFETs in each)**




- all on the same side of PCB
- Top side cooling
- integrated heatpipe
- up to 10kW

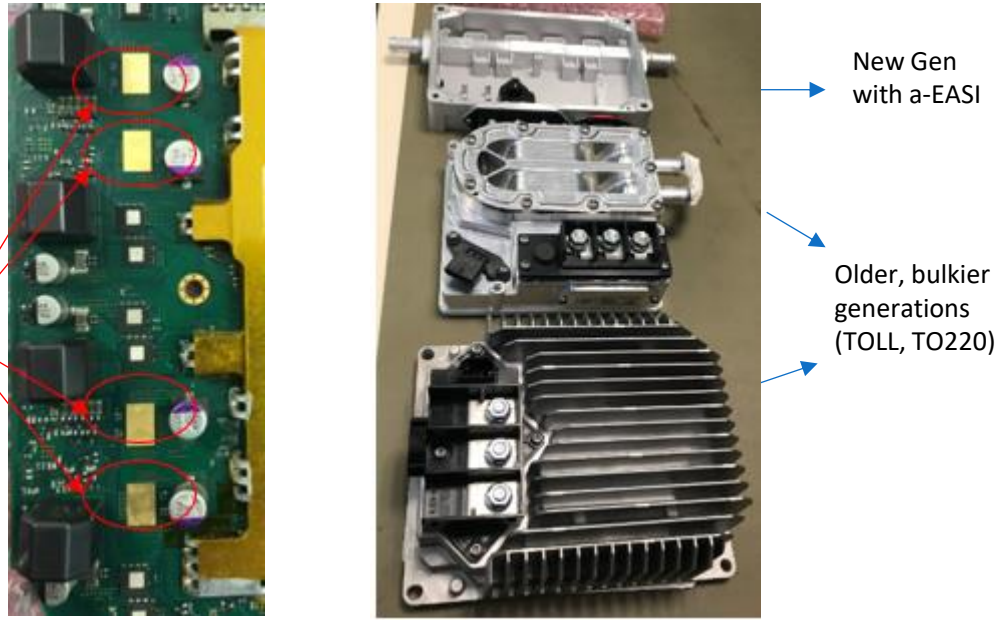
# Modularization with a-EASI IC embedding

**Example of a demonstrator for mid-power module (DCDC converter)**

- Smaller, lighter device
- Higher efficiency

Power Module

Heatsink covers



# Summary

- ATV semiconductors require a new packaging technology to fully demonstrate its advantage on the efficiency, reliability and field application
- a-EASI (chip embedded) technology is designed and developed for this task since 2010, more 120M unit shipment till today
- We expect the new wafer technology + new packaging paves the way for the proliferation of ATV power application

# Thank You

www.aseglobal.com