

Murata Integrated Passive Solutions

Automotive Presentation 2021





Our Business

We are worldwide leaders in the design, manufacture and supply of electronic components and solutions.

We are Innovators in Electronics.

Our Strengths

- Advanced materials technology and expertise
- Broad product portfolio
- Extensive global manufacturing and sales network

Our Figures

- Established in 1944
- Net sales 1,630,193 million JPY*
- Number of subsidiaries. 89* (29 in Japan, 60 overseas)
- Employees 75,184*

**as of March 31, 2021*

**Murata Manufacturing Co., Ltd. Is not included in the number of subsidiaries*

Murata Integrated Passive Solutions



- Part of Murata since October 2016
- Murata Integrated Passives division
- Manufacturing & Innovation center

EMEA (16)

The Netherlands

- | | |
|------------|------------------|
| Finland ▲● | Spain |
| France ▲● | Switzerland |
| Germany | United Kingdom ● |
| Hungary | |
| Italy | |

Americas (23)

United States

- | | |
|----|--------|
| ▲● | |
| ● | Brazil |
| ● | Canada |
| | Mexico |

(No of companies)
Regional Head Offices

- ▲ Production plants
- R&D Centers

Japan (55) ▲●

Greater China (37) ▲●

Asia and others (19)

Singapore ▲

- | | |
|---|-------------|
| | India |
| ▲ | Malaysia |
| ▲ | Philippines |
| ▲ | Thailand |
| ▲ | Vietnam |

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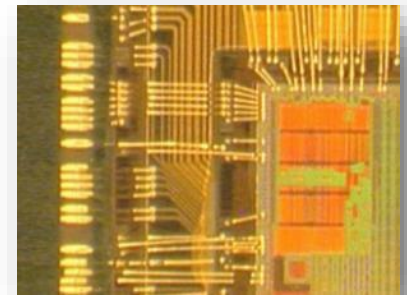
People

- 150 employees / 60 engineers
- High expertise in Microelectronics
- Design – Manufacturing - Support



Manufacturing

- Own wafer fab of 21'000 sqm
- Leading edge Silicon Capacitors and Integrated Passive Devices



Technology

- Patented innovative technology
- Miniaturization and performance
- Recognized Quality

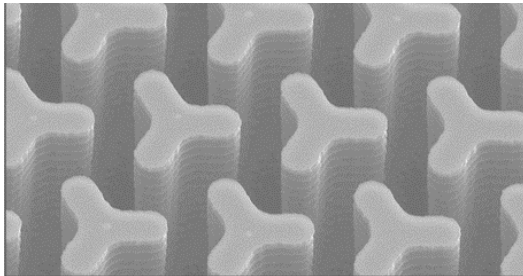


3D Silicon Capacitors

3D:

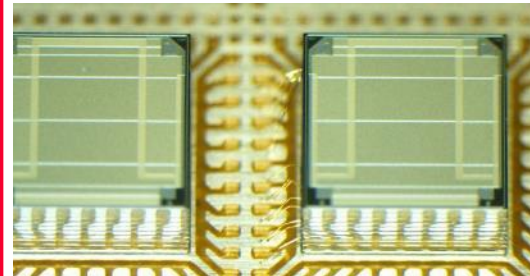
We have invented a unique technology based on **3D structures**.

These 3D structures enable unprecedented **integration** and **miniaturization** of capacitors.



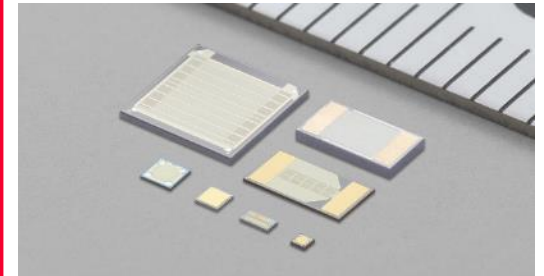
Silicon:

Our technology is based upon **silicon** components. Silicon capacitors can reach **outstanding performances** in stability, frequency and temperature.



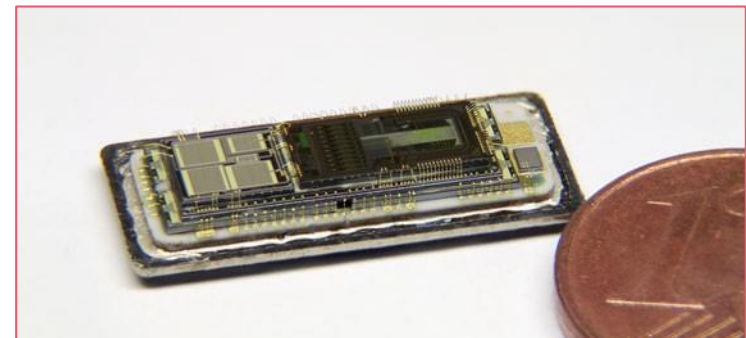
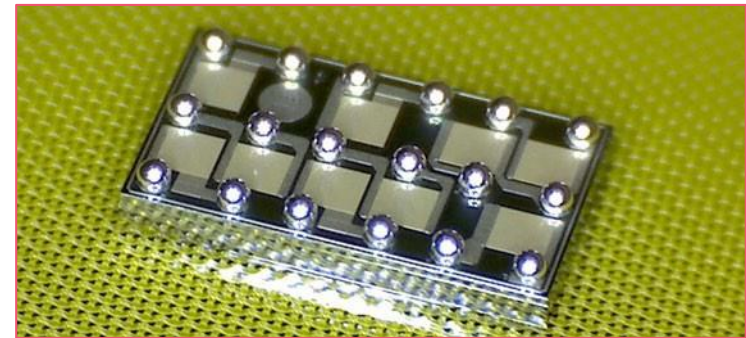
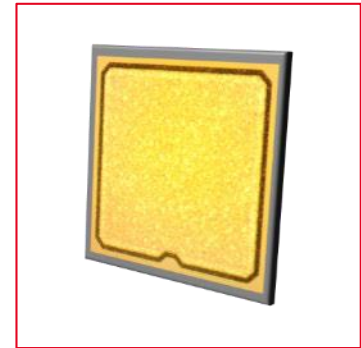
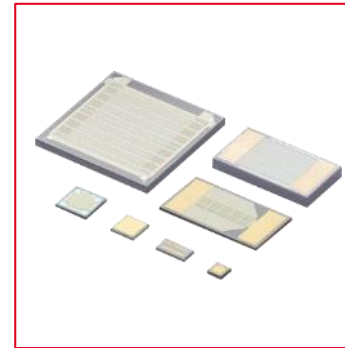
Capacitors:

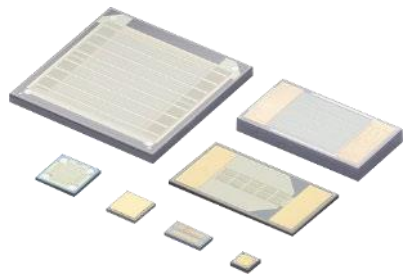
We are specialized in integrating **passive components (custom and off-the-shelf products)**, with a strong focus on high performances **capacitors**.



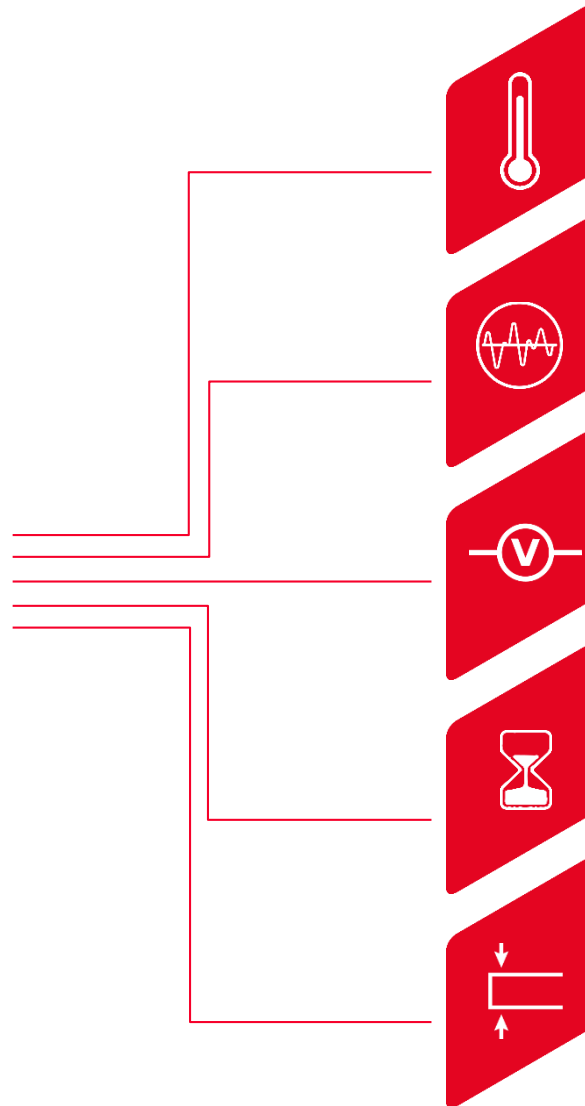
From standard to fully customized solutions

- **Stand alone and standard components :**
horizontal and vertical capacitors
- **Component arrays:**
combination of several passive components into a single silicon die
- **Interposers:**
use of semiconductor assembly technologies to build high performance 3D structures





Silicon Capacitors



High stability in temperature
Up to **250°C** environments



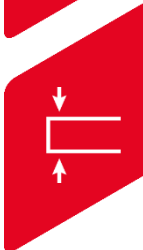
Signal stability over frequency
Up to **110 GHz** applications



Stability regarding voltage
For **900 V** applications

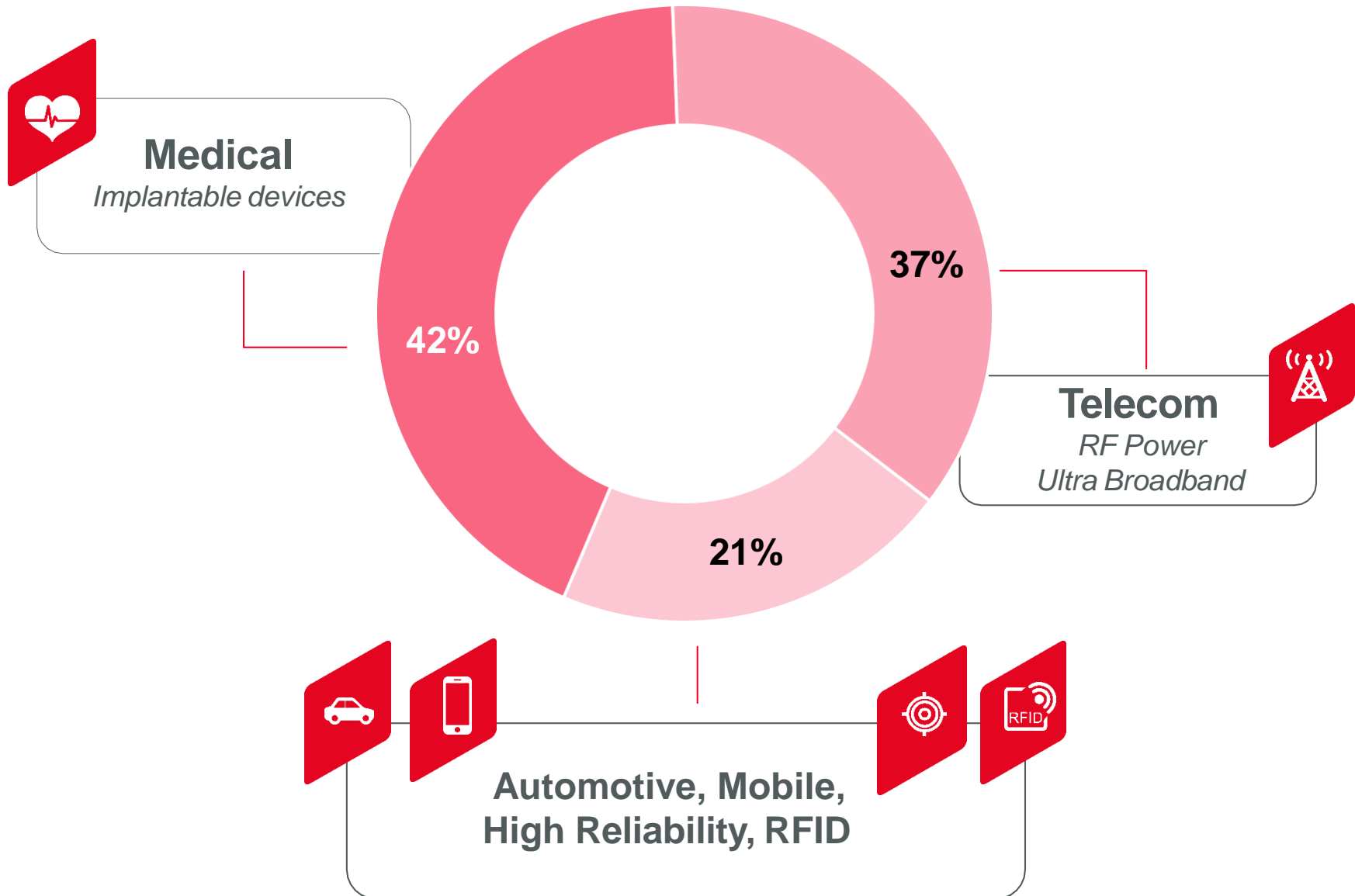


Stability over ageing
Minimum lifetime of **10 years**



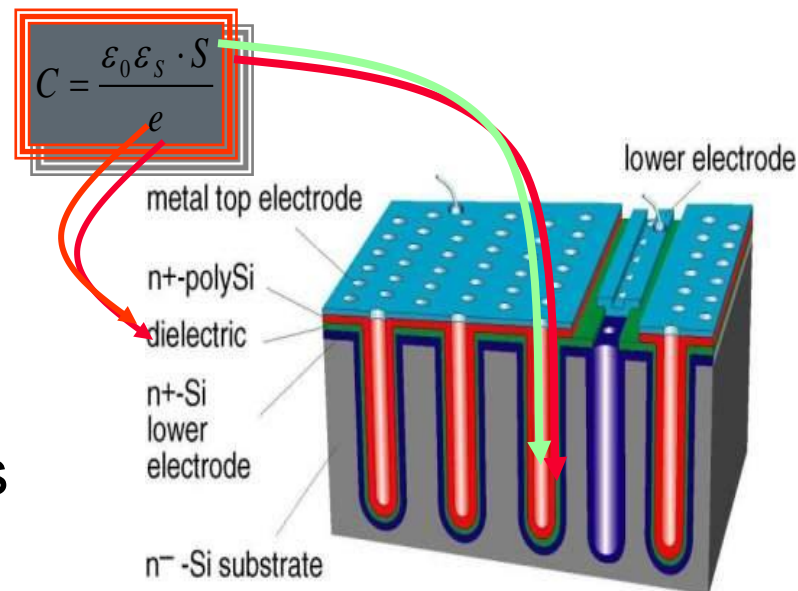
Extreme low thickness
Down to less than **50 µm**

We serve different innovative markets



Key features for highly integrated Capacitors

- Increase the effective capacitor surface by etching 3D structures with high aspect ratio.
- Suitable high k material with appropriate deposition techniques
 - High permittivity
 - High breakdown voltage > 10V
 - Low leakage current
 - Excellent linearity vs temperature (62ppm/C°) and voltage (100ppm/V)
 - High reliability

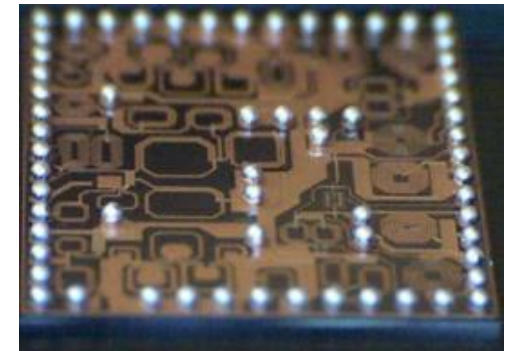
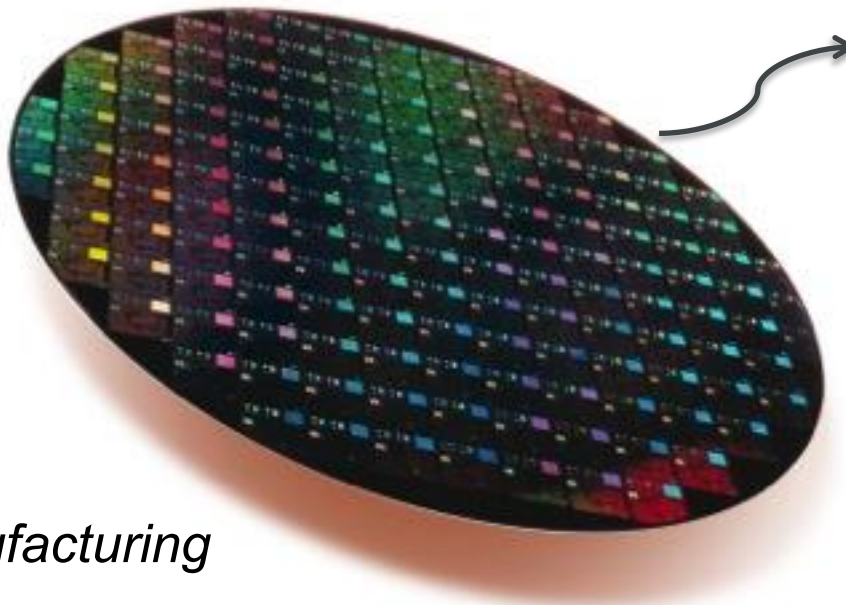
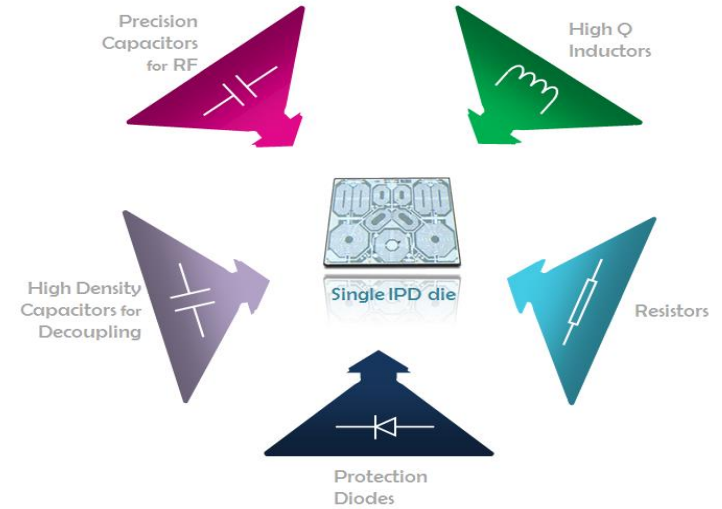




What is an IPD?

Integrated Passive Devices (IPD) for

- Medical
- Industrial
- Aerospace
- Automotive



IPD

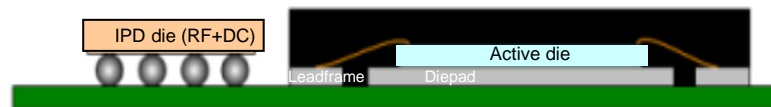
6" wafer manufacturing

Impact on Packaging and components

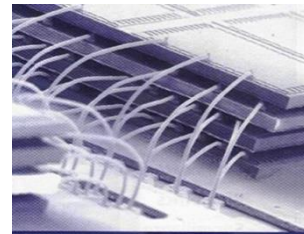


MIS offers a unique path to « re-think » the overall assembly.

From die integration...



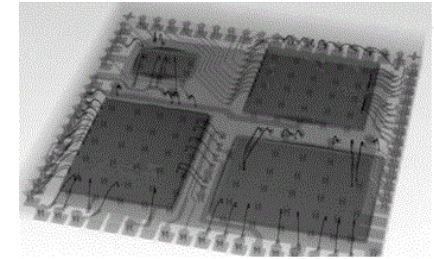
Bumped Companion Chip



Stacked Dies

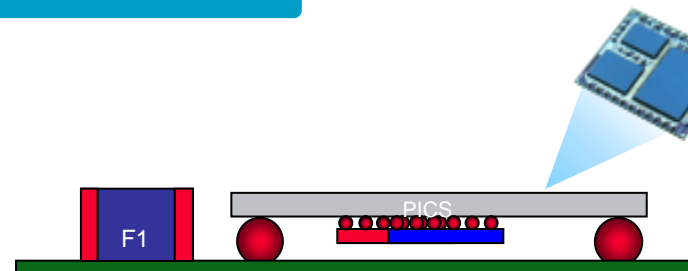


Embedded Dies



SiP

...to interposer solutions



Interposer & WLP

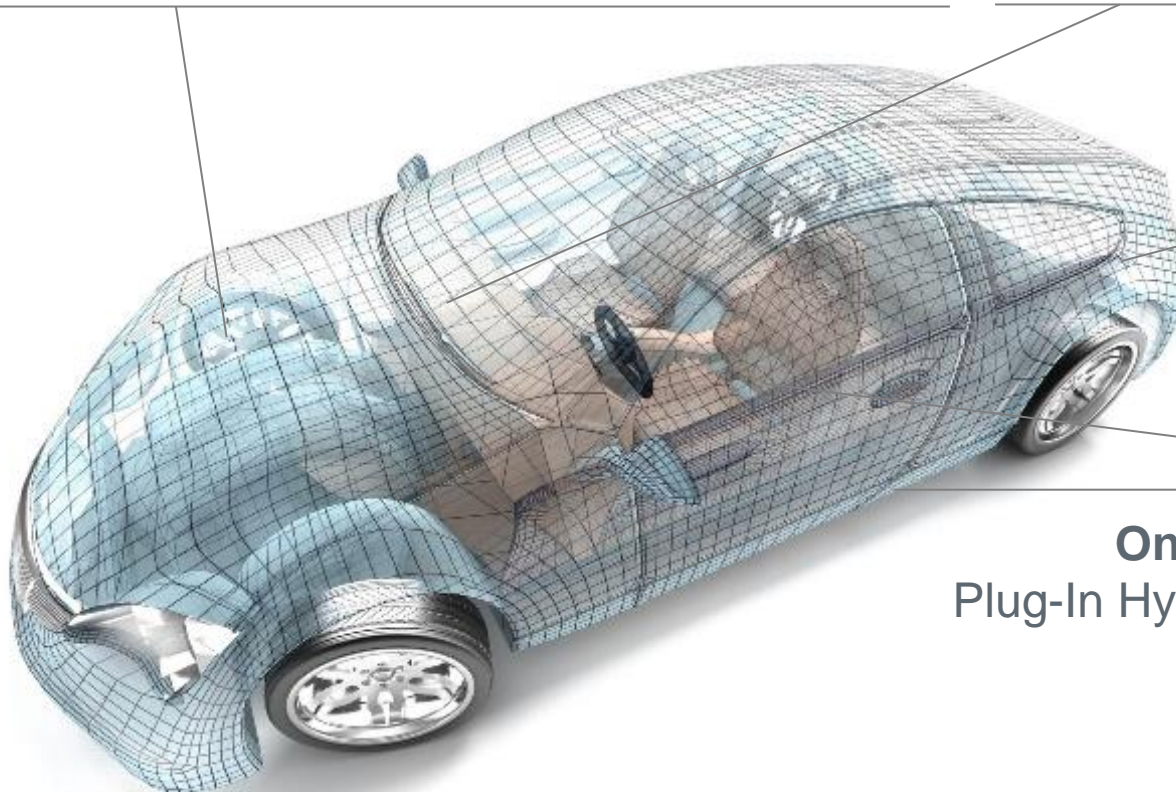
SiCap interest in Power Electronics

xEV Inverter Motor Driver
Main Motor Driver, Sub Motor Driver

DC/DC Converter
12V, 24V, 800V ECU System

**Compressor
Motor Driver**

On Board Charger
Plug-In Hybrid System, EV System



WBG power switching challenges

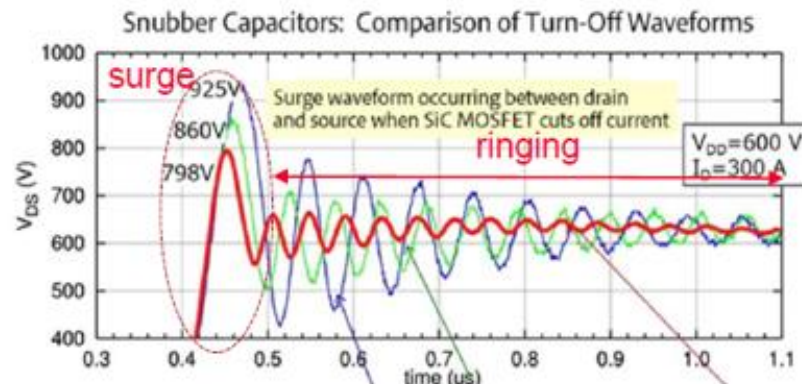
A. Surge Voltage ➡ Lifetime & Reliability

1/ parasitic L on DC bus

2/ SW junction recovery (IGBT, SiC, GAN ...)

B. Ringing ➡ EMI

1/ complex resonance of parasitic L and C



Need ➡ Damping surges and lowering ringing frequencies

Solution ➡ Integration of low ESL components and innovative packaging

Sicap interest in ADAS Technology

mm wave Rader

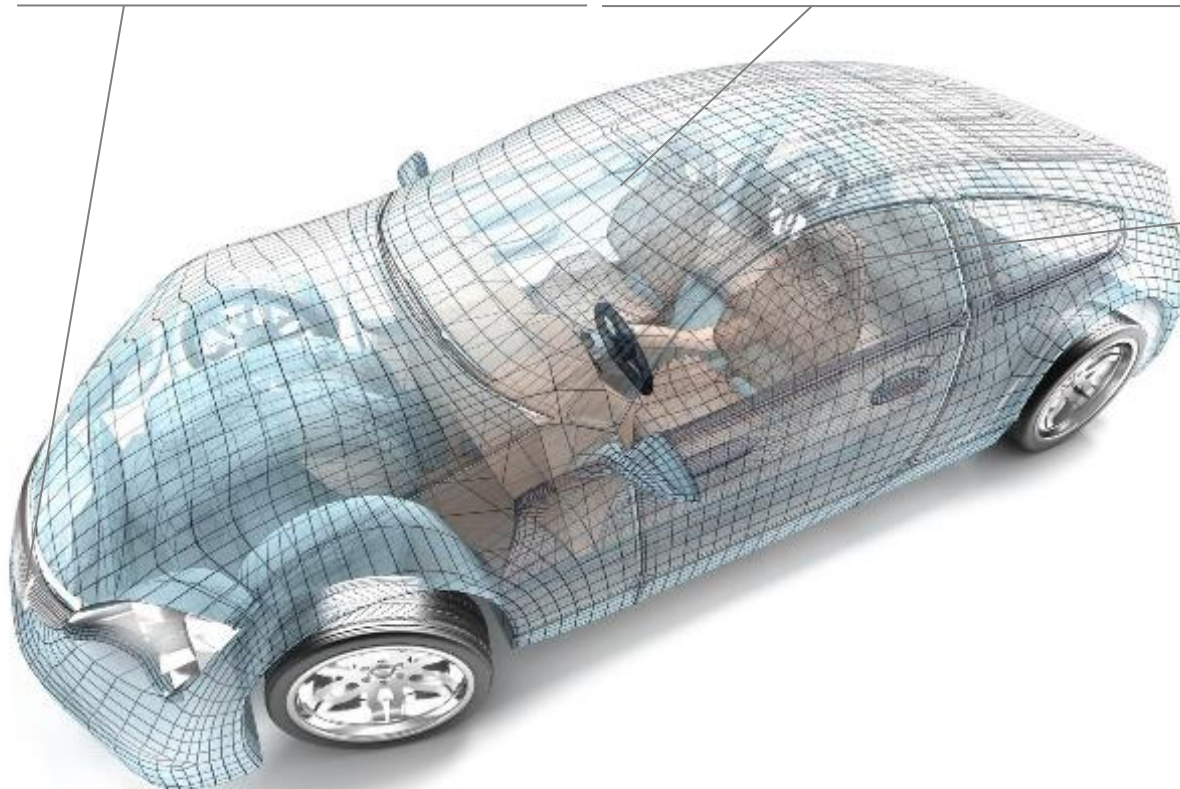
Long distance detection
in front of the car.

Camera, Stereo Camera

Detection of the near field Obstacle and the figure

LiDAR

3D measurement of
the obstacle



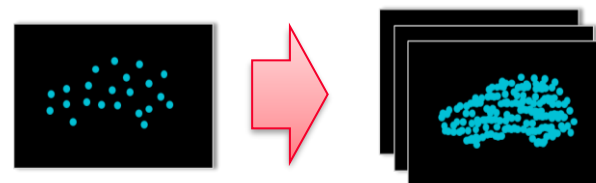
Requirement to Pulse generating capacitor LiDAR

Needs for LiDAR

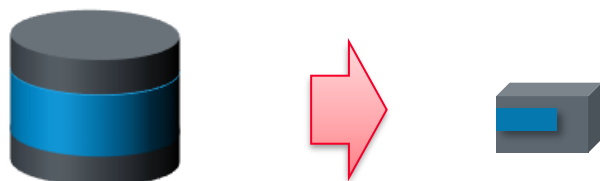
Longer Distance Detection



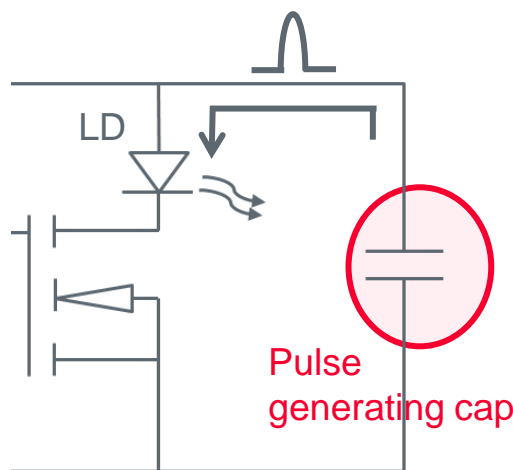
More Accurate 3D Structure



Miniaturization of device



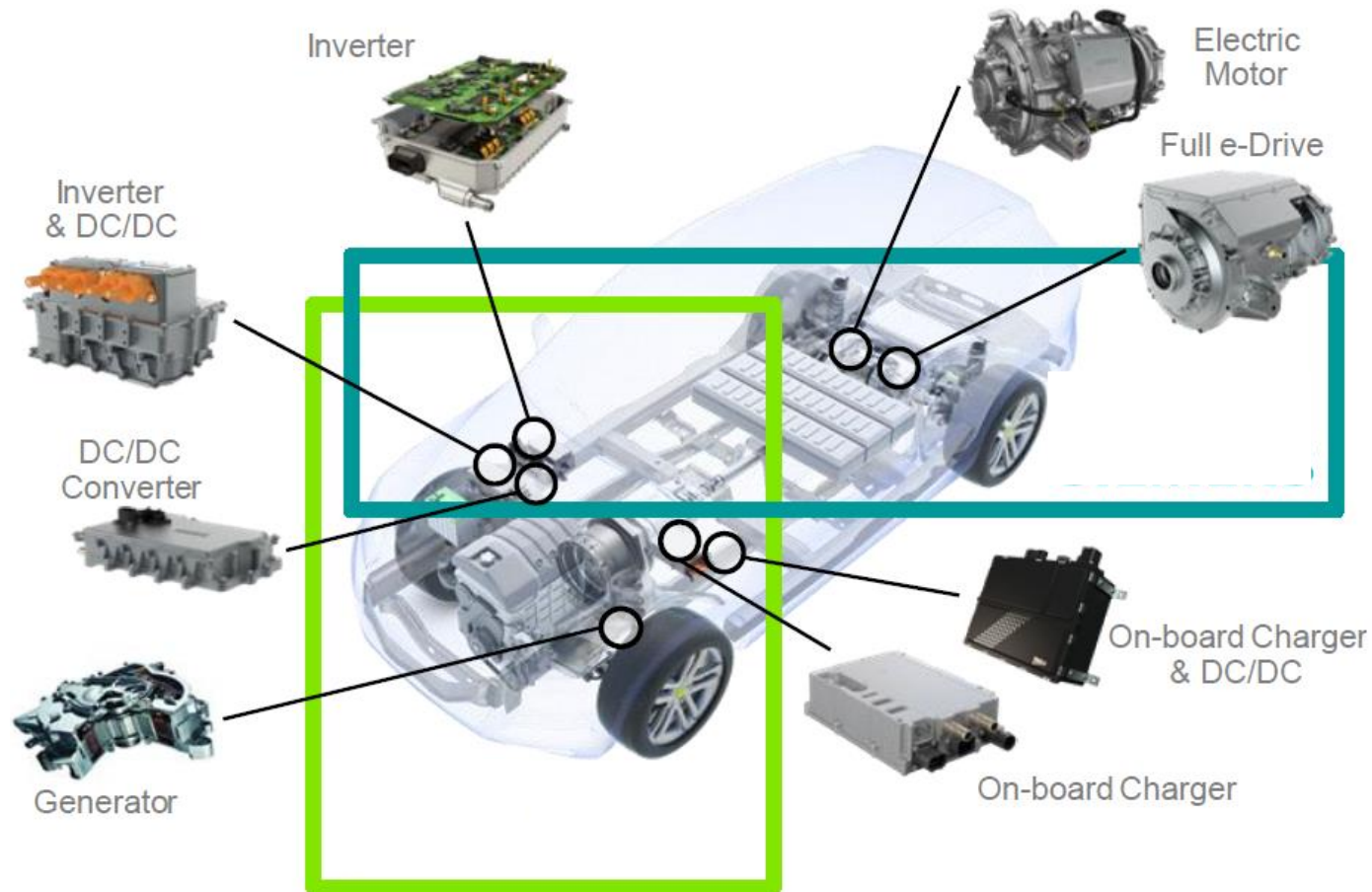
Less misdetection



Requirement to Pulse generating cap

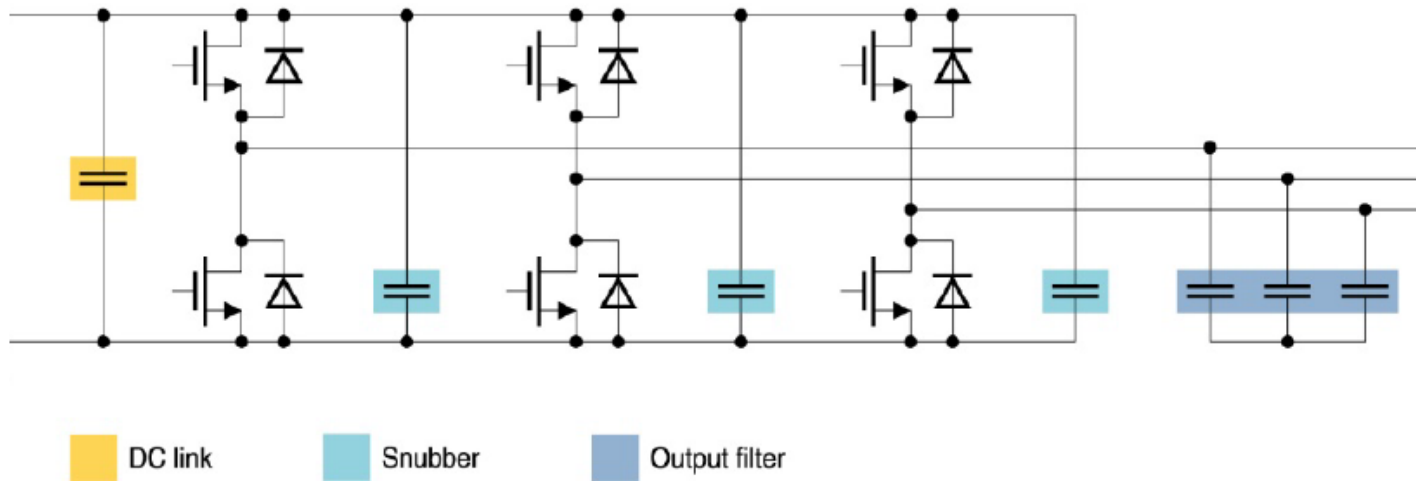
- ① Miniaturization of loop ESL in LD drive circuit
- ② Small size with keeping high capacitance value
- ③ Stable performance to voltage/temperature
- ④ Space saving

High Power Electrification



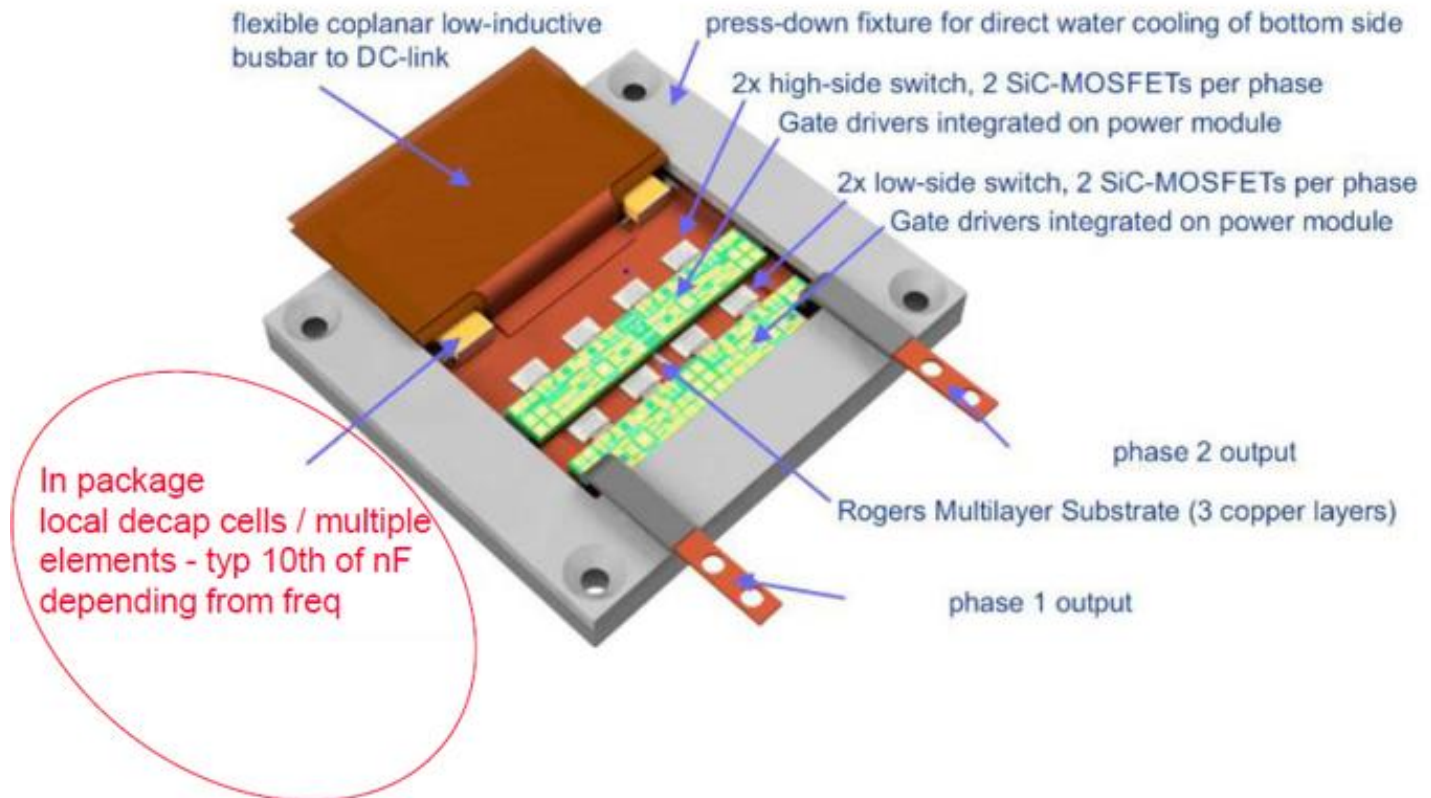
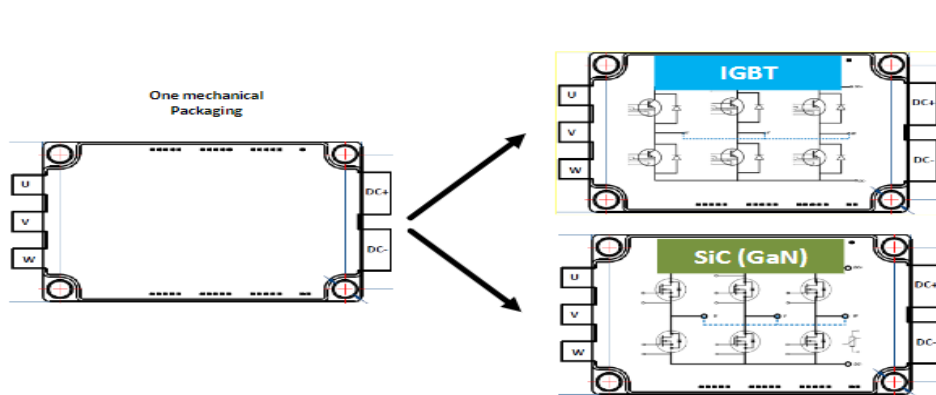
Typical application

Multi phase converter / inverter



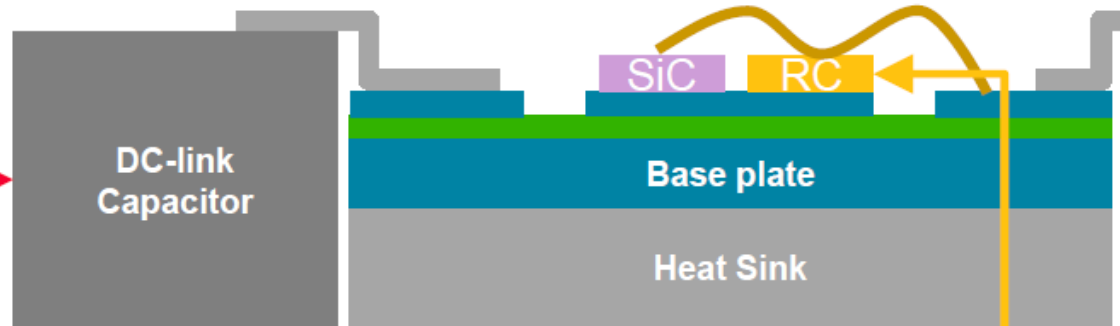
Power Module integration

Inverter



Capacitors synergy (800V DC bus)

Both snubber capacitor and DC-link capacitor act together to reduce surge voltage and ringing.



- DC bulk to catch low frequency
- Requires large cap value

- MIS-target*
- ☑ Local decap to catch high freq = surge + EMI
 - Requires low ESR AND low ESL

DC-LINK Capacitor

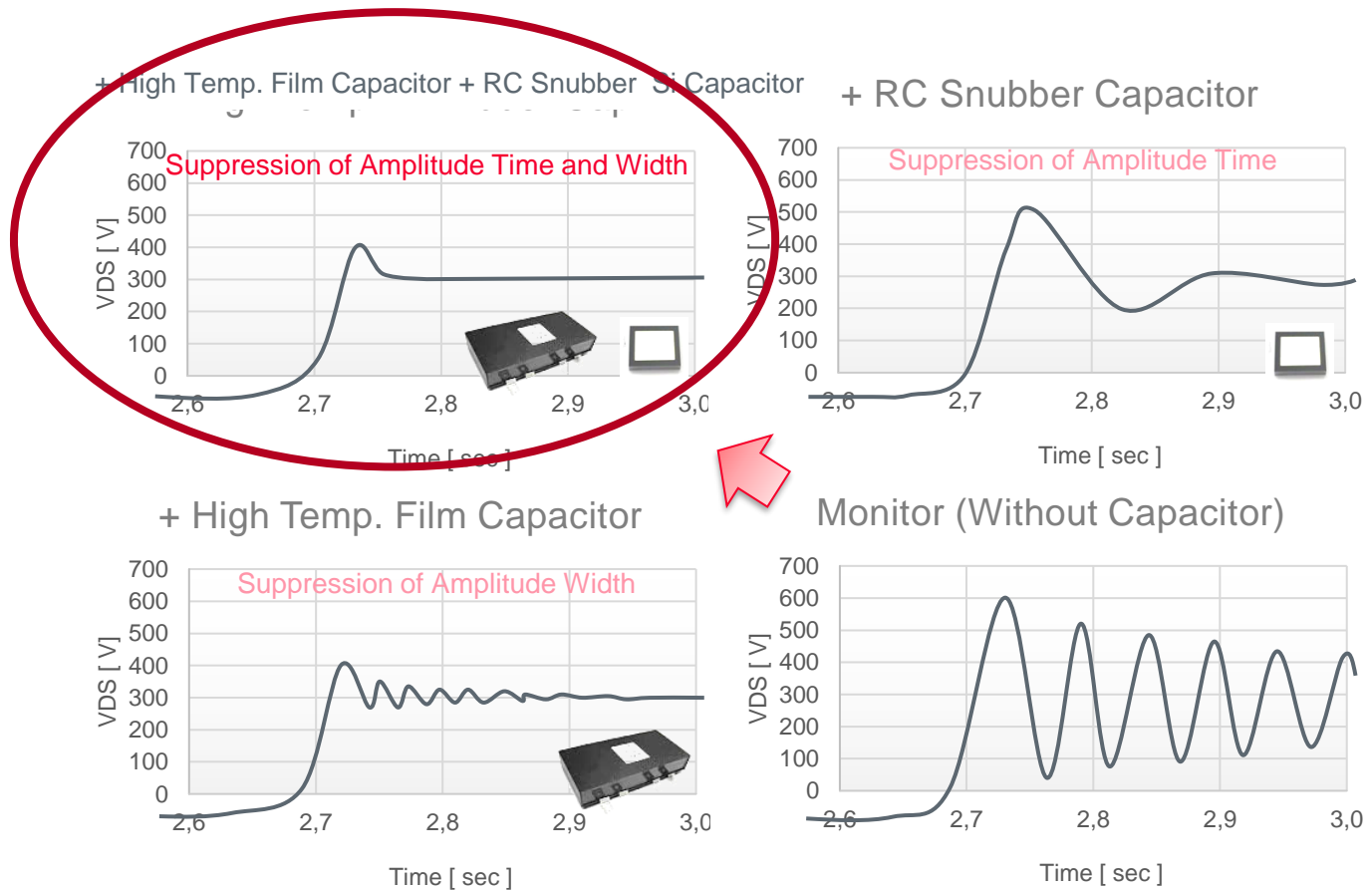
HTFC
e.g.) WV:DC ~900 V,
125°C,
LowESL <10nH

Snubber Capacitor with optional Resistor



CR Device
e.g.) WV:DC 1.3kV,
200°C,
3~5nF, 5~10Ω

RC Snubber +DC Link benefits

Expected Improvement by New Solutions




Snubber availabilities

	Available RC Snubber	Next Dev'
Breakdown Voltage	BV900 and BV1200	BV1200
Operating voltage	From 500V to 1kV	
Temperature	Up to 175°C	
Capacitance values	BV1200 : 1.6nF, 2.5nF BV900 : 3nF	BV1200 : 5.4nF
R values (ohm)	2; 5; 10; 20 ohms	1; 2; 5; 10 ohms
Size	3 x 3	5 x 4
		

Customized solutions (Form factor, RC values, metalization ...) available on request

FH series Introduction

	Single element Type	Customized Module Type
Working Voltage	500Vdc, 850Vdc ※4uF/500V and 850V product are under development	
Temperature	125°C @hottest point (continuous)	
Capacitance	500Vdc: 4, 10, 15, 20μF 850Vdc: 10, 14uF	Custom
Case size	Please refer to following page	Custom
Allowable Ripple	500V/10μF: 6 Arms (10kHz, @105deg)	Custom
Shape		 Multi-terminals / Multi-elements
M.P.	500Vdc/10, 15, 20uF: Available 500Vdc/4uF: 2021 Q3 850Vdc/10.14uF: 2023~	2023~

◆ HTFC advantage: High-temperature resistance + Downsizing

■ Conventional film capacitor: PP

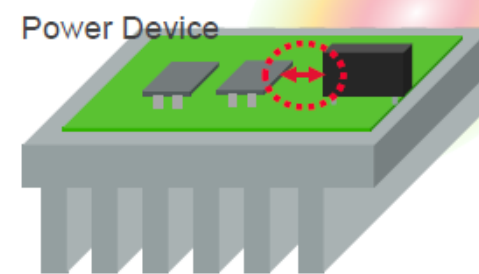
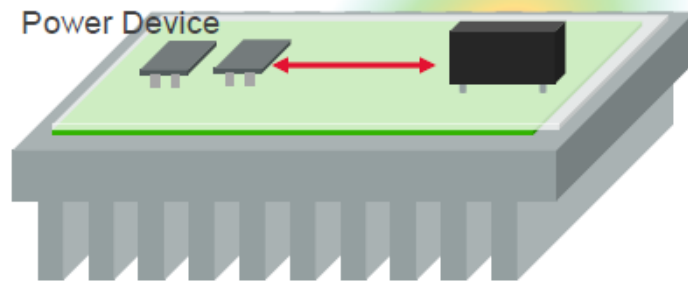
■ Murata film capacitor: HTFC

Challenges

Housing size
Heat resistance
(~ 105°C)

Benefits

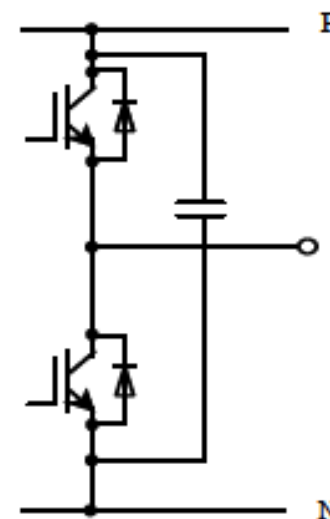
Simple cooling system
High-density mounting
Design flexibility



System downsizing



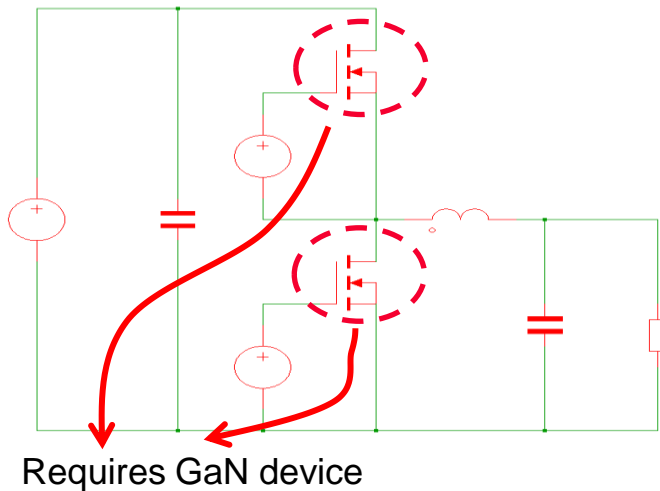
- **Future trend** : Development of OBC converters using **WBG** technology for high efficiency
- **WBG** devices with high frequency operation
 - PFC 100-200kHz
 - DCDC 200-500kHz
- **Challenges** :
 - Embedding the Capacitor for lower ESL Loop
 - Surge & Damping issues (see above slides)
 - High voltage reliability
 - Thermal performances
 - Miniaturization

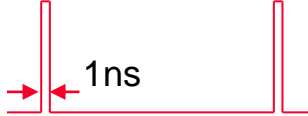


DC/DC Converter 400V-12V

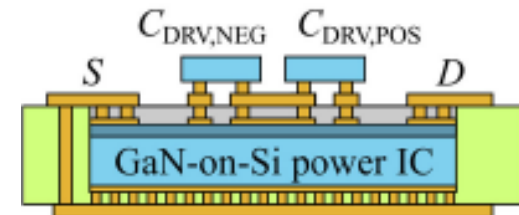


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INNOVATOR IN ELECTRONICS



For very high switching frequencies $> 100\text{MHz}$
GaN Fet will be needed.
Ultra short pulse will be required. 

Low parasitic inductance will be Key
Embedding of FET and add Low ESL capacitors






The placement of Murata Low ESL silicon capacitors placed directly above the pads of the GaN Embedded FET allow to decrease overall Parasitic inductance.

OFFERING :

As on-package gate-loop decoupling flip-chip capacitors : UBSC 0201M 10nF

As in-package gate-loop decoupling embedded capacitors : ATSC 0202 10nF BV30

Mid volt product availabilitiesr availabilities

	BV30	BV100	BV150
Breakdown Voltage	BV30	BV100	BV150
Operating voltage	16V	33V	48V
Temperature	Up to 200°C	Up to 200°C	Up to 200°C
Capacitance values	1nF to 1μF	1nF to 100nF	100pF to 4.7nF
AECQ qualification	YES	On going	YES
Assembly	Wirebonding/ Embedding	Wirebonding/ Embedding	Wirebonding/ Embedding
			

Customized solutions (Form factor, C values, metalization ...) available on request

Automatic Driving System Technology

mm wave Rader

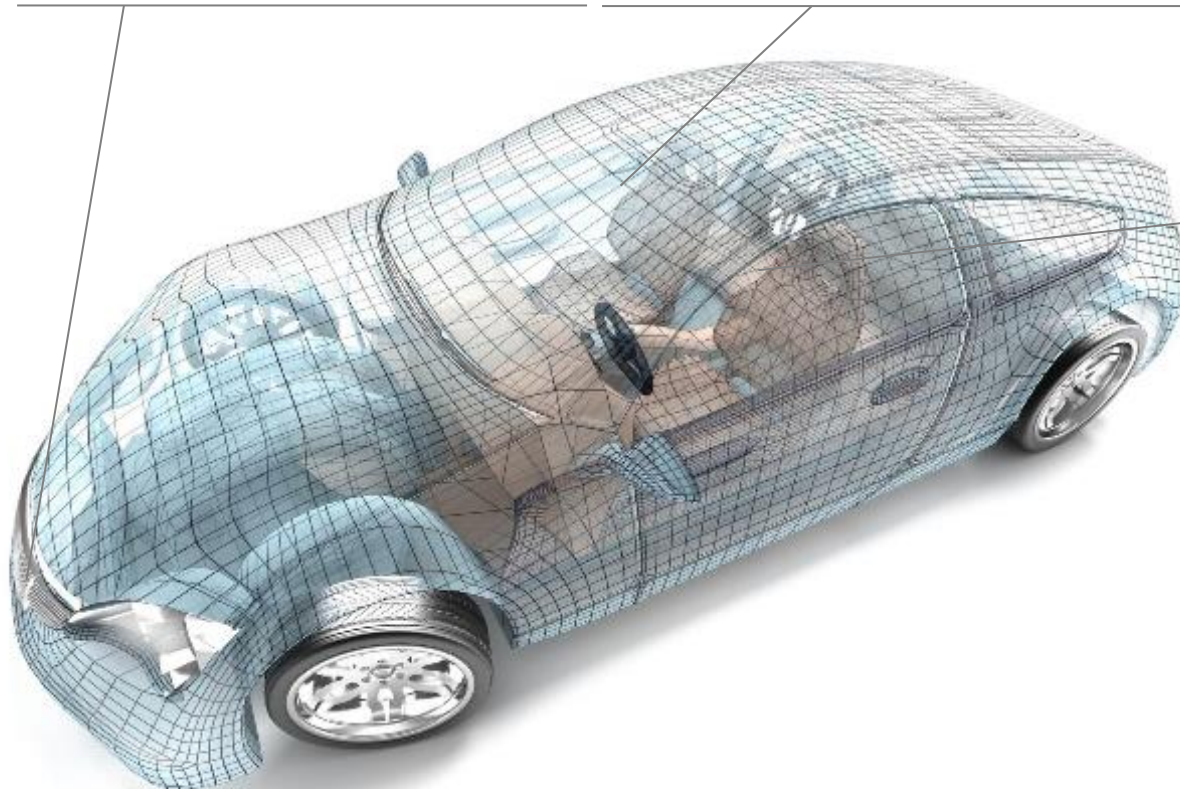
Long distance detection
in front of the car.

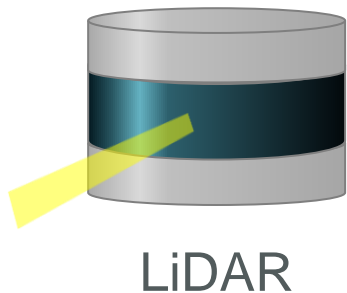
Camera, Stereo Camera

Detection of the near field Obstacle and the figure

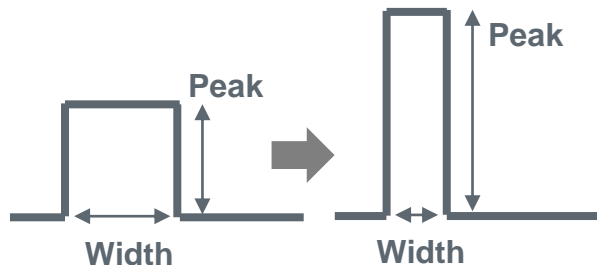
LiDAR

3D measurement of
the obstacle



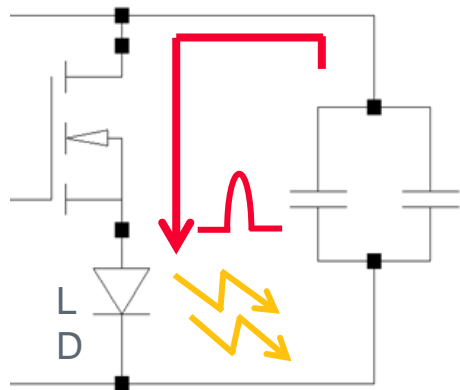


Longer sensing distance is required



Needs Trend

- Higher peak & Shorter pulse width
- Stability of pulse
- High reliability

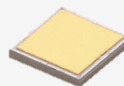


Discharged pulse from capacitors flow LD and generate laser pulse

Needs Trend for discharge capacitor

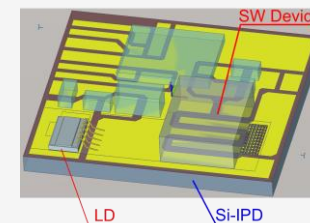
- Low ESL design
- Stability of Capacitance
- AEC-Q100?

Si-cap Wire bondable



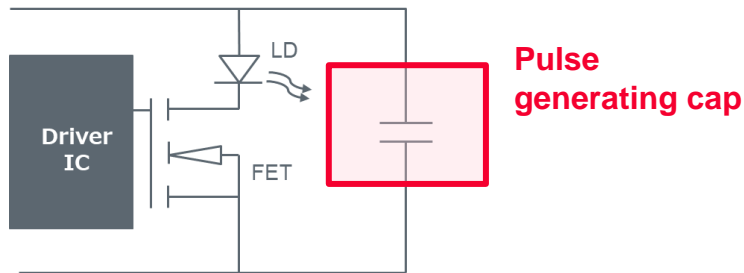
0202 size, 1nF(BV150)
0302 size, 470pF(BV450)

Si-interposer

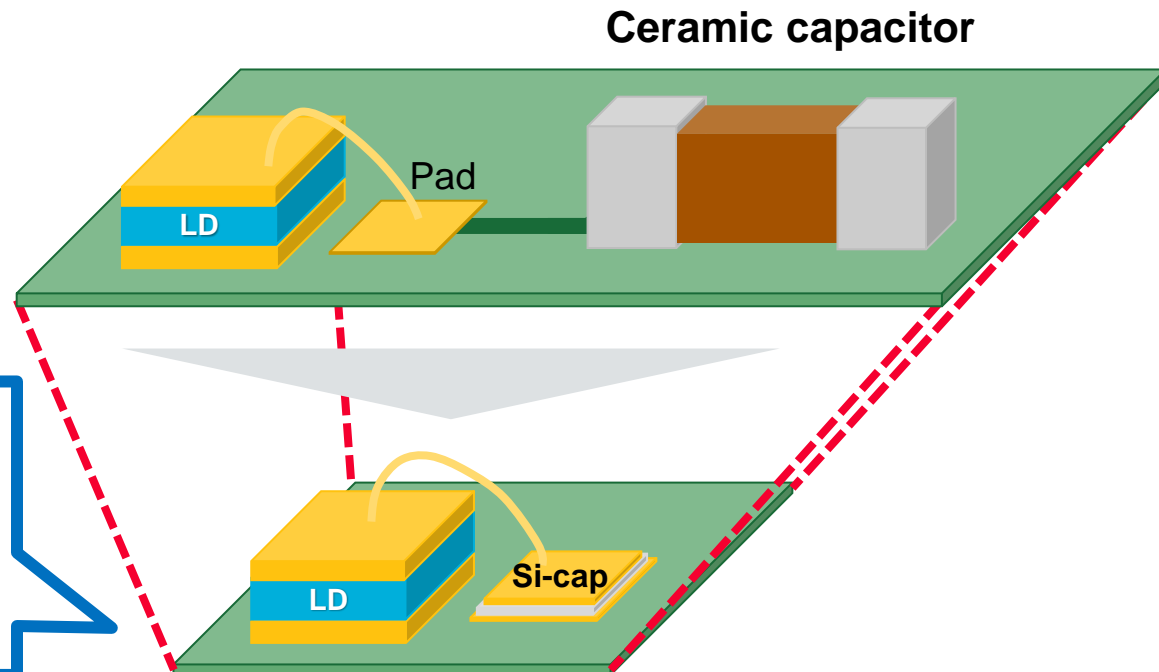


① Si-cap solution

Design optimization for Miniaturization by direct wire-bonding with laser diode.



Design optimization by using SICAP for lower loop ESL (Target 100pH) & miniaturization.

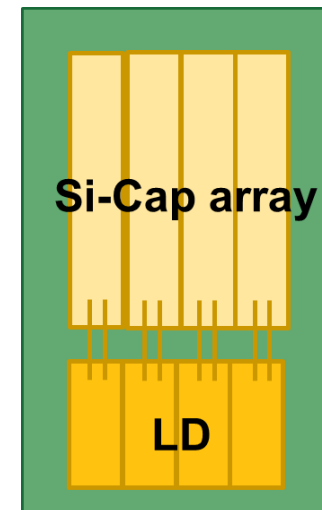
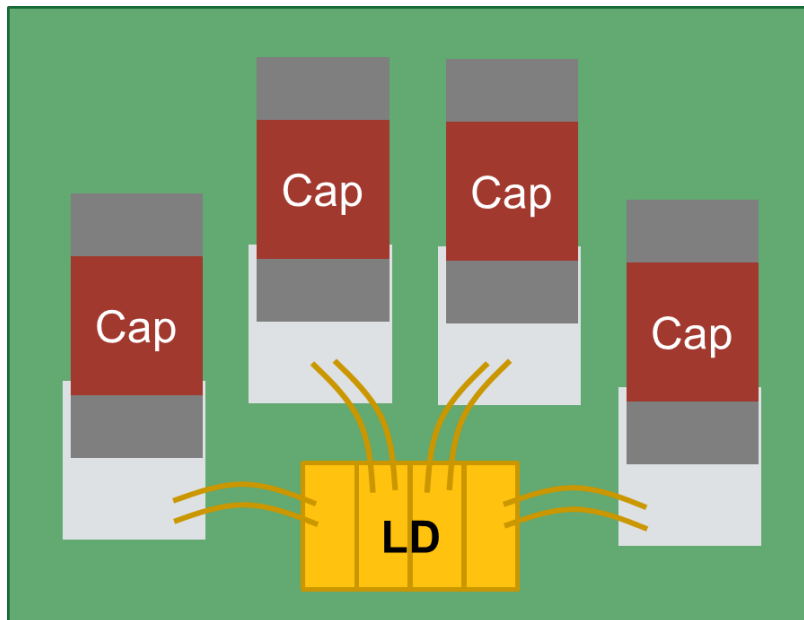
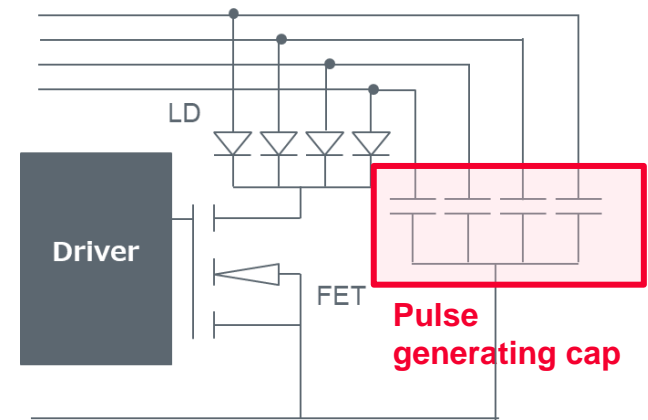


WASC series
Standard SICAP for wire-bonding
BV150 1nF 0202

② Custom Si-cap array solution for Multi-ch design

Design optimization for **Miniaturization & Low Loop Inductance** by flexible customization of dimension & direct wire-bonding with laser diode.

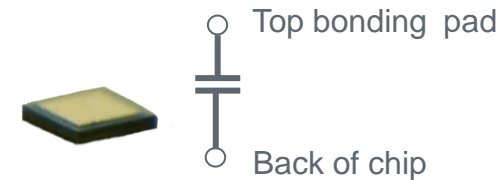
Simultaneously Driving of Multi channel LD



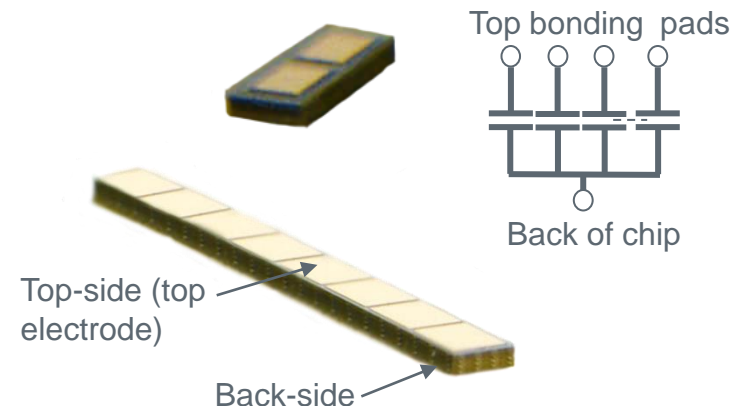
Capacitor Array (Custom Design)

- Wire bondable
- Single capacitor or capacitor array
- Physical parameters:
 - Small form factor supported: 1/1 to 1/8
 - Flexible size: *from 0.010 inches square to 32 inches square*
 - Thickness: *250μm (as low as 100μm)*
 - Substrate: *Silicon with gold backing*
 - Dielectric: *Silicon dioxide / Silicon nitride*
 - *Various Top electrode(s) finishings possible like Aluminum, Gold, ...*
- Electrical parameters
 - Capacitance range: few pF to several 10's nF
 - Low ESR < 10mΩ and Low ESL < 10pH allowing a wideband matching
 - Good reliability across wide temperature range
 - No piezo electric effect distorting the excellent linearity

➤ Single Element

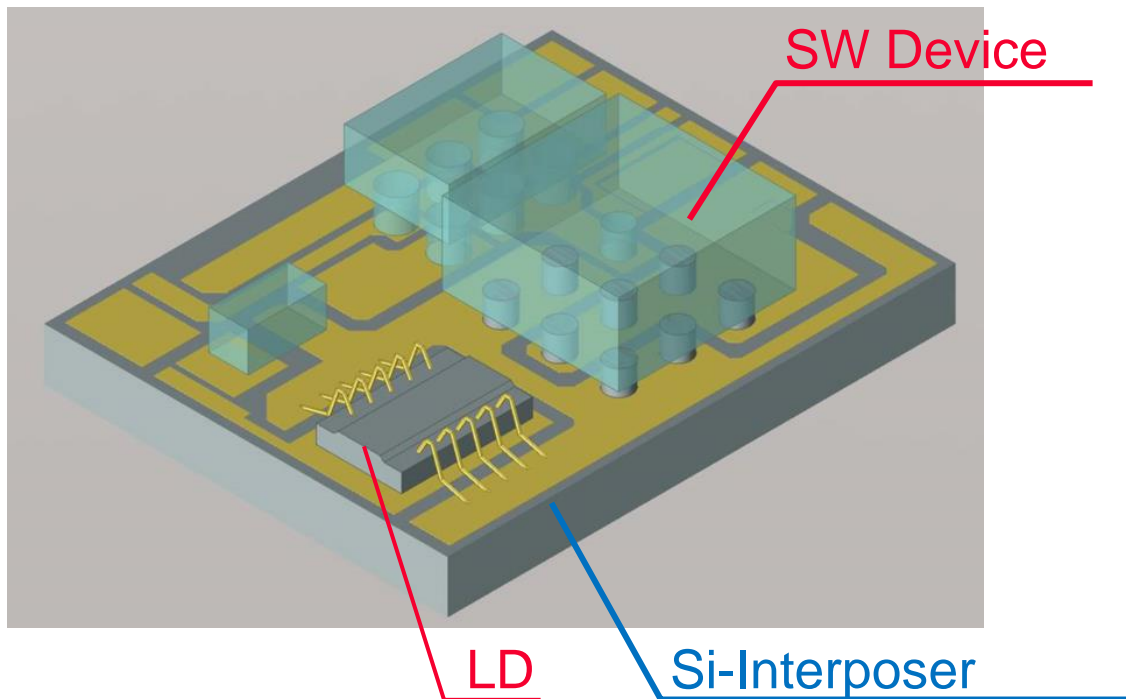


➤ Capacitor Array



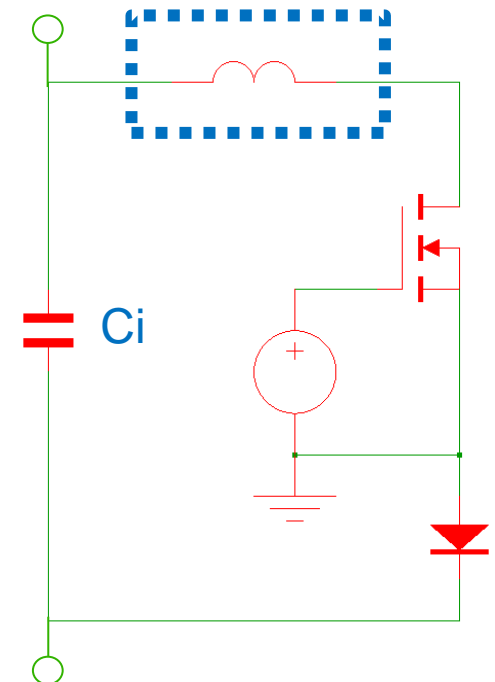
③ Custom interposer solution for high output power *muRata* INNOVATOR IN ELECTRONICS

Minimize Loop Inductance.



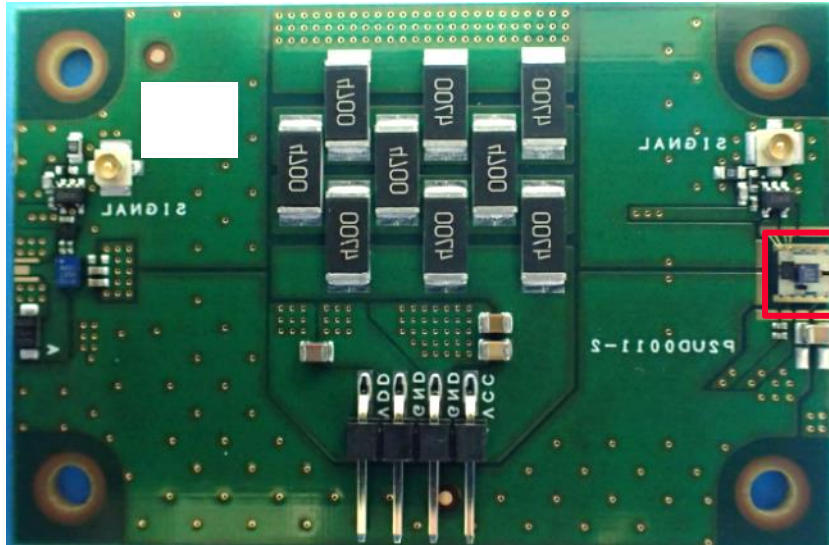
By forming cap & wiring pattern in Si-interposer
By placing LD • Driver IC • SW device on Si interposer.

Reduce the parasitic inductance as much as possible
(Target is less than 100pH)

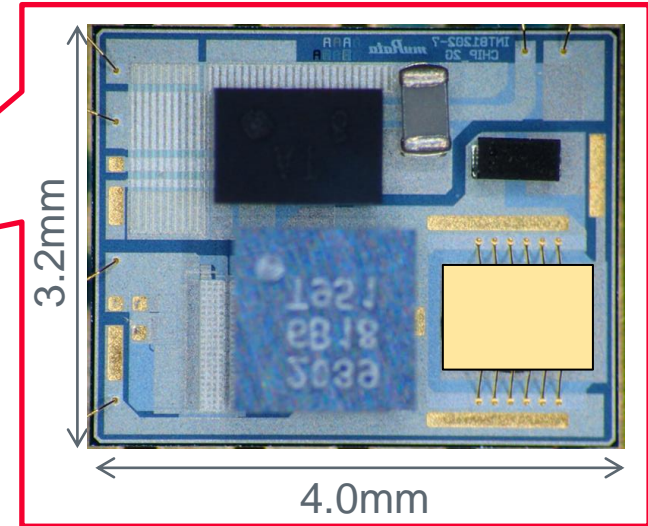


Measurement condition of interposer

Si-IPD prototype for LD drive Measured LD light Output



Evaluation board



Si-IPD prototype for LD drive

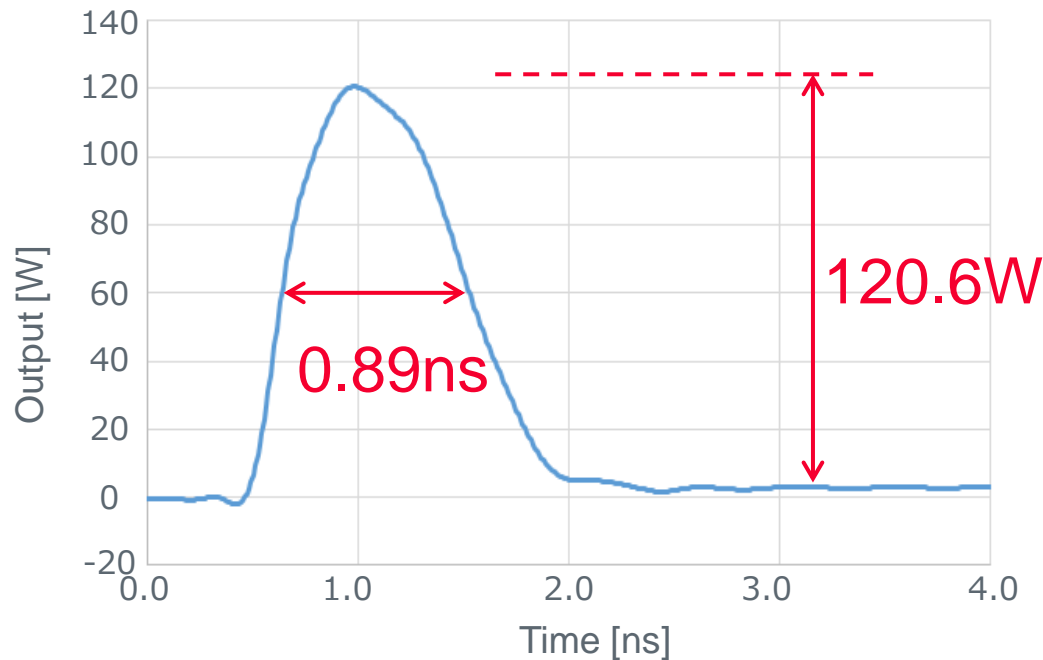
Used Parts

Capacitor : Si-Cap [approx.1nF] in Si-IPD
LD : ***** (100W, 35A)
GaN FET : EPC2039 (EPC)
Driver IC : LMG1020 (TI)

Measurement condition

Measure LD light output by JIS C 6180
O/E converter: DET08C/M (Thorlabs, BW=5GHz)
Oscilloscope: MSO64 (Tektronix, BW=4GHz)
Power meter: PS19Q (Coherent, Thermopile Sensors)

Evaluation result of interposer solution



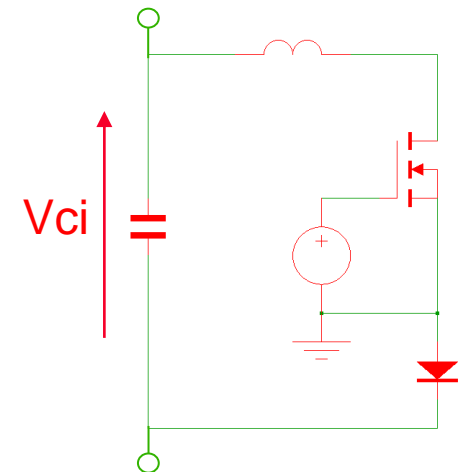
LD output Waveform

Input Voltage(= Initial V_{ci}) : 60.0V

LD light output FWHM : **0.89ns**

LD light output Peak : **120.6W**

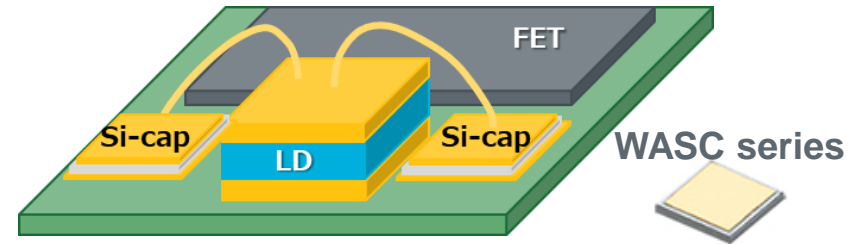
20% Higher power than targeted 100W
<1ns pulse width



Summary

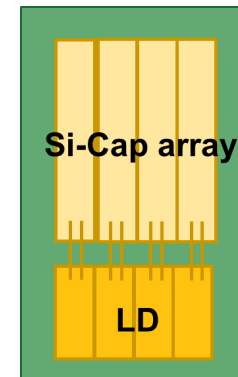
Si-cap (Vertical Cap.)

Design optimization for Miniaturization by direct wire-bonding with laser diode.



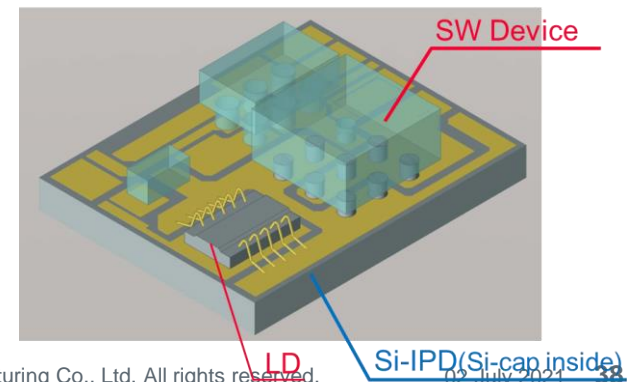
Custom Si-cap array (Vertical Cap.)

Design optimization for Miniaturization & Low loop inductance by flexible customization of dimension, direct wire-bonding with laser diode.



Custom Si-IPD (Si Interposer)

Extremely low loop inductance to satisfy Narrow pulse & High output power by forming cap and wire inside Si interposer.



Thank you!

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