



Potential of the 3D stacking power SoC for high frequency switching applications

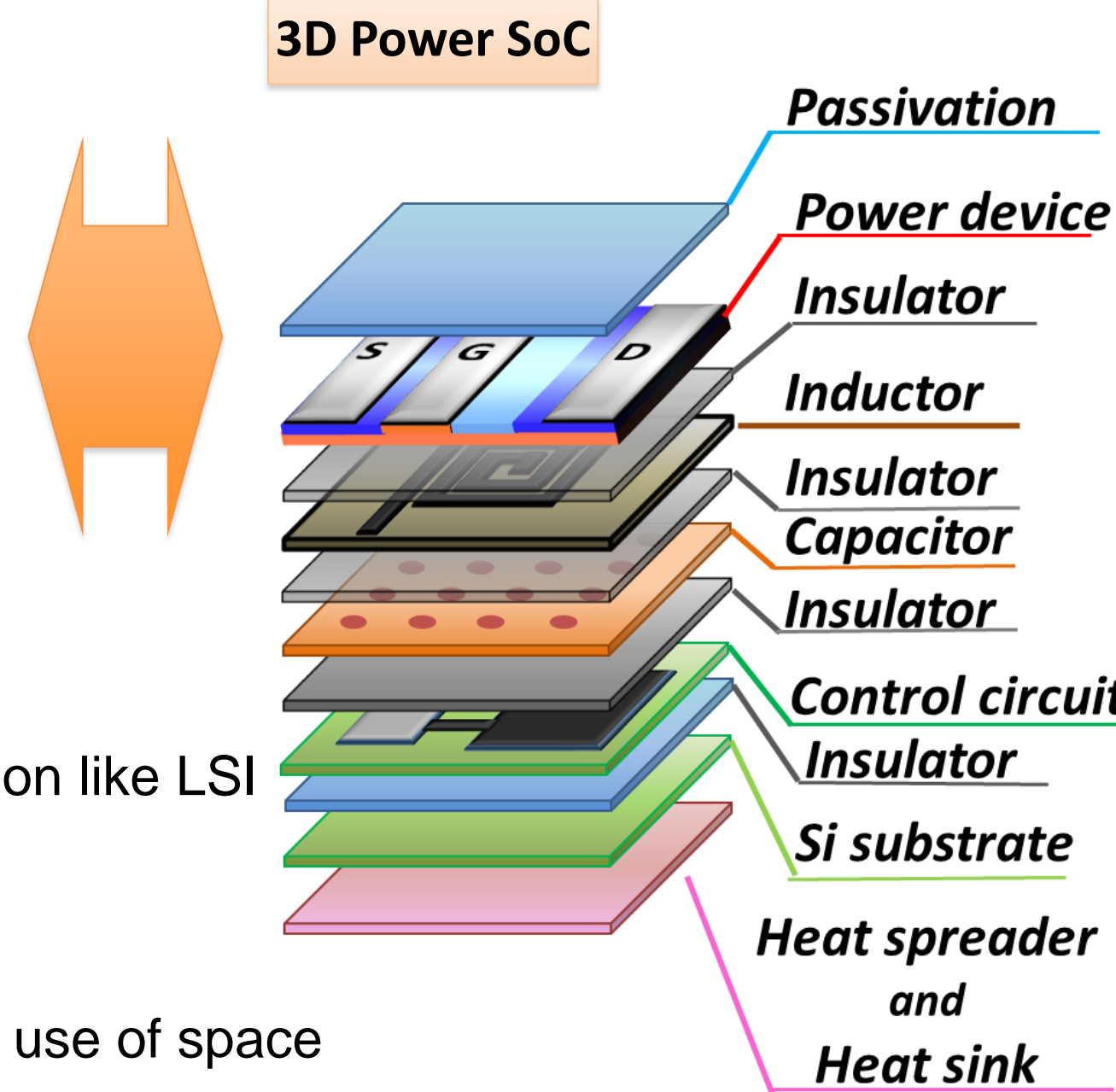
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Introduction

Market demand of power supply

- High speed response
- High efficiency
- Reduction in Size and Weight
- Reduction in Cost

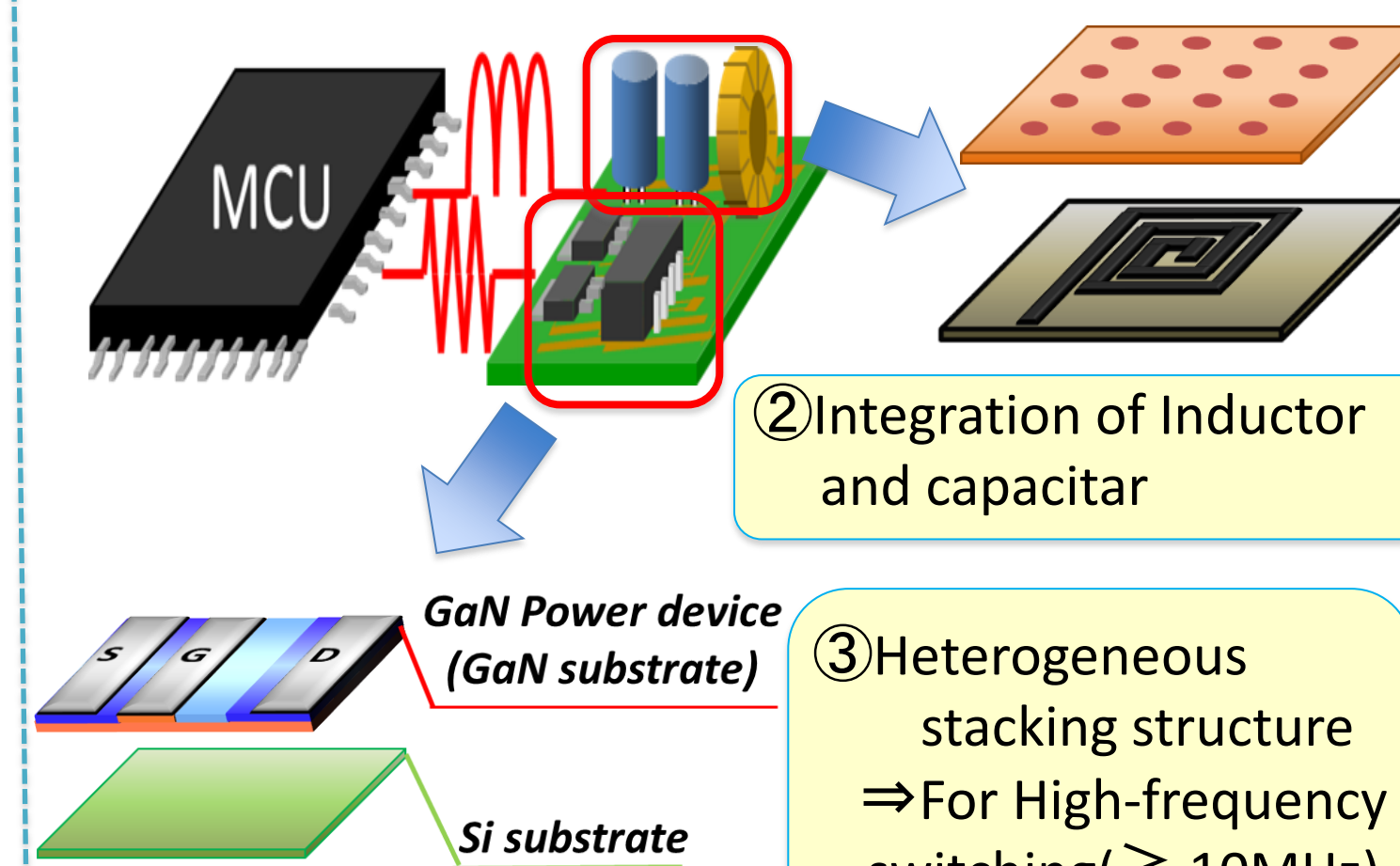


3D Power SoC's Advantages

1. Cost reduction ⇒ Mass production like LSI
2. Size and weight reduction
3. High efficiency
4. High performance ⇒ Stable operation and efficient use of space
5. Heterogeneous structure

Challenges and Approaches

① Minimize parasitic inductance ⇒ For High efficiency



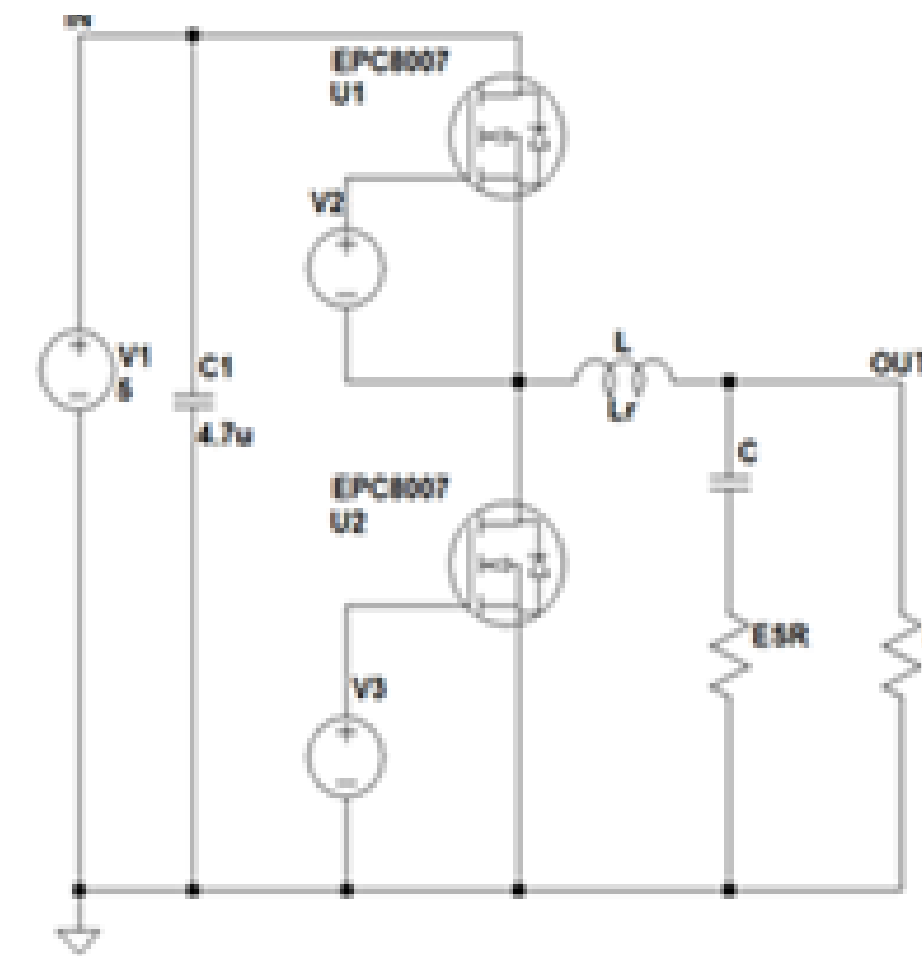
② Integration of Inductor and capacitor

③ Heterogeneous stacking structure ⇒ For High-frequency switching ($\geq 10\text{MHz}$)

✓ We propose 3D stacking power SoC which stacks Si-LSI with GaN power device.

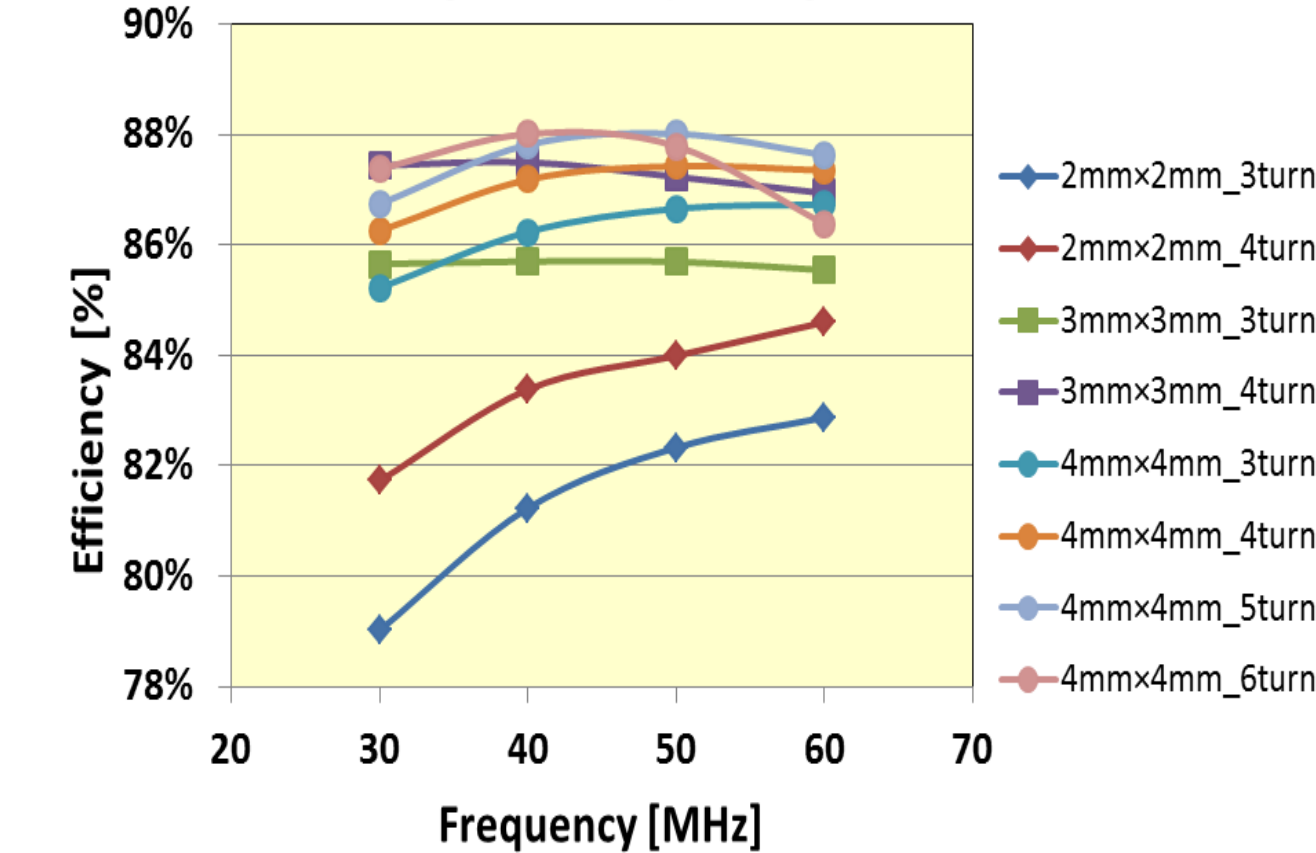
Simulation of 3D stacking power SoC

Simulation circuit

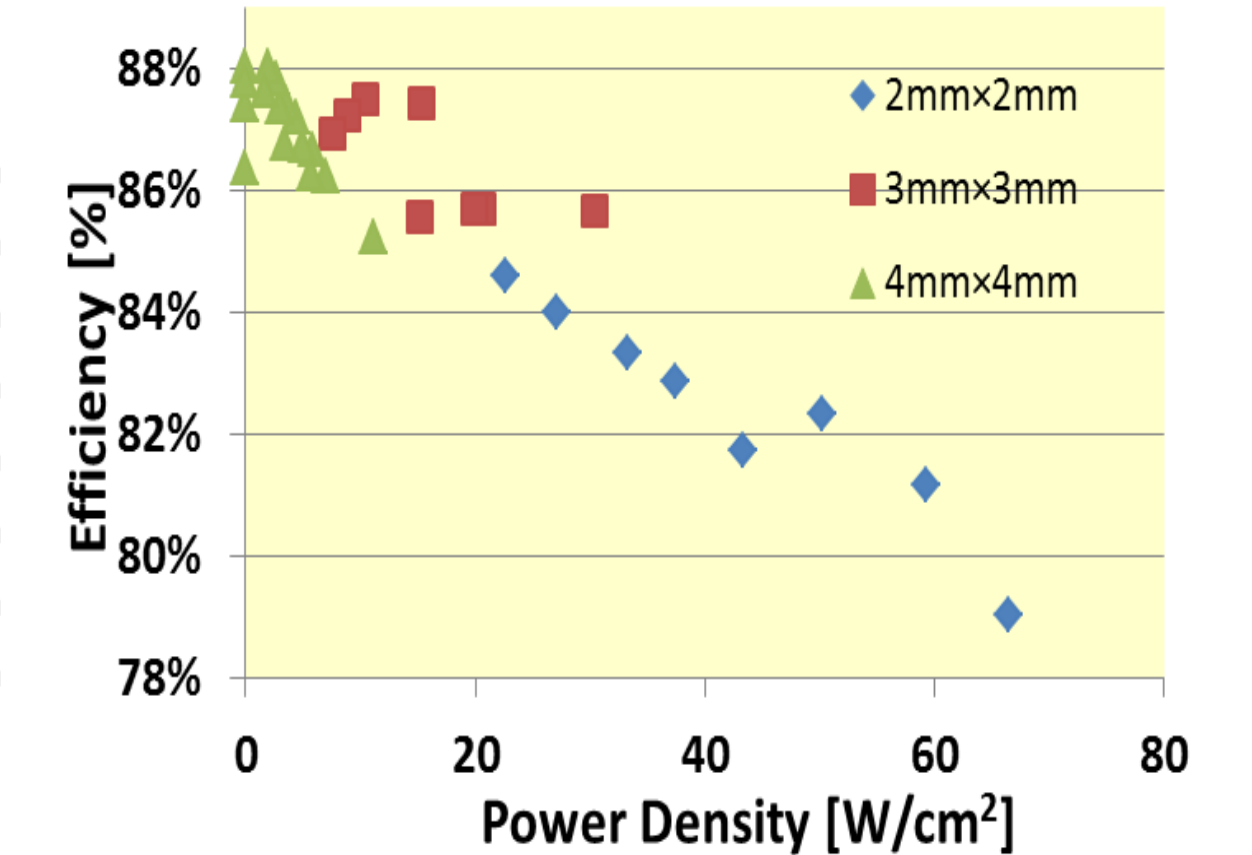


Simulation result

Efficiency vs Frequency



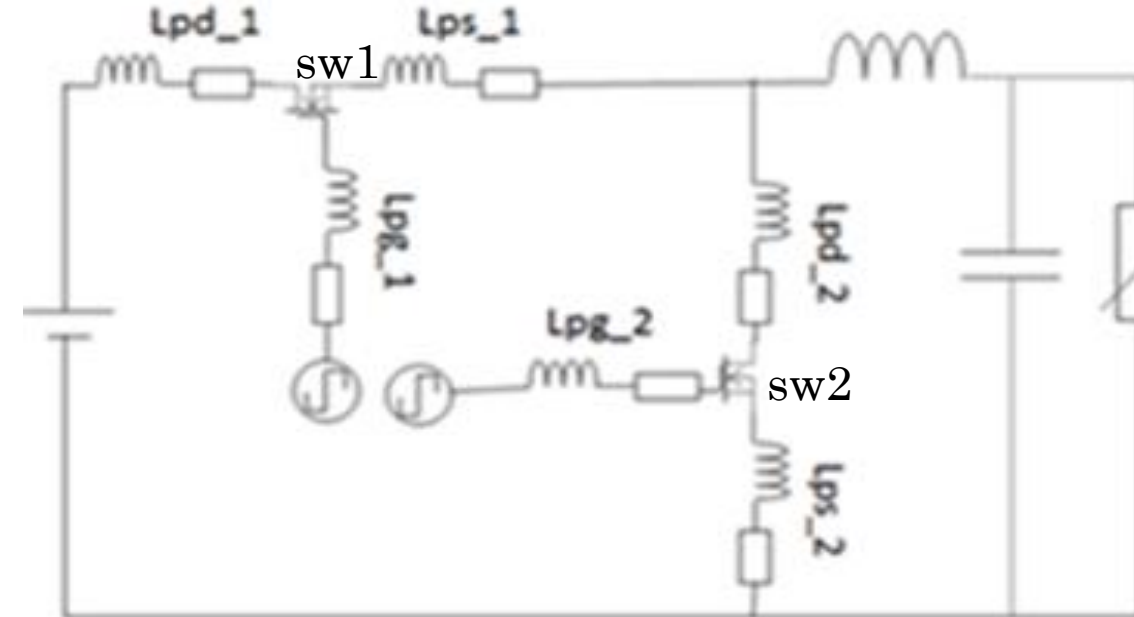
Efficiency vs Power Density



- ✓ Highest efficiency ⇒ 4mm X 4mm , 5 turn and 6 turn
- ✓ Output power ⇒ 4mm X 4mm , 5 turn : 0.312W / 4mm X 4mm , 6 turn : 0.297W

Comparison of 3D power SoC and state-of-the-art GaN based DC-DC converter

Simulation circuit



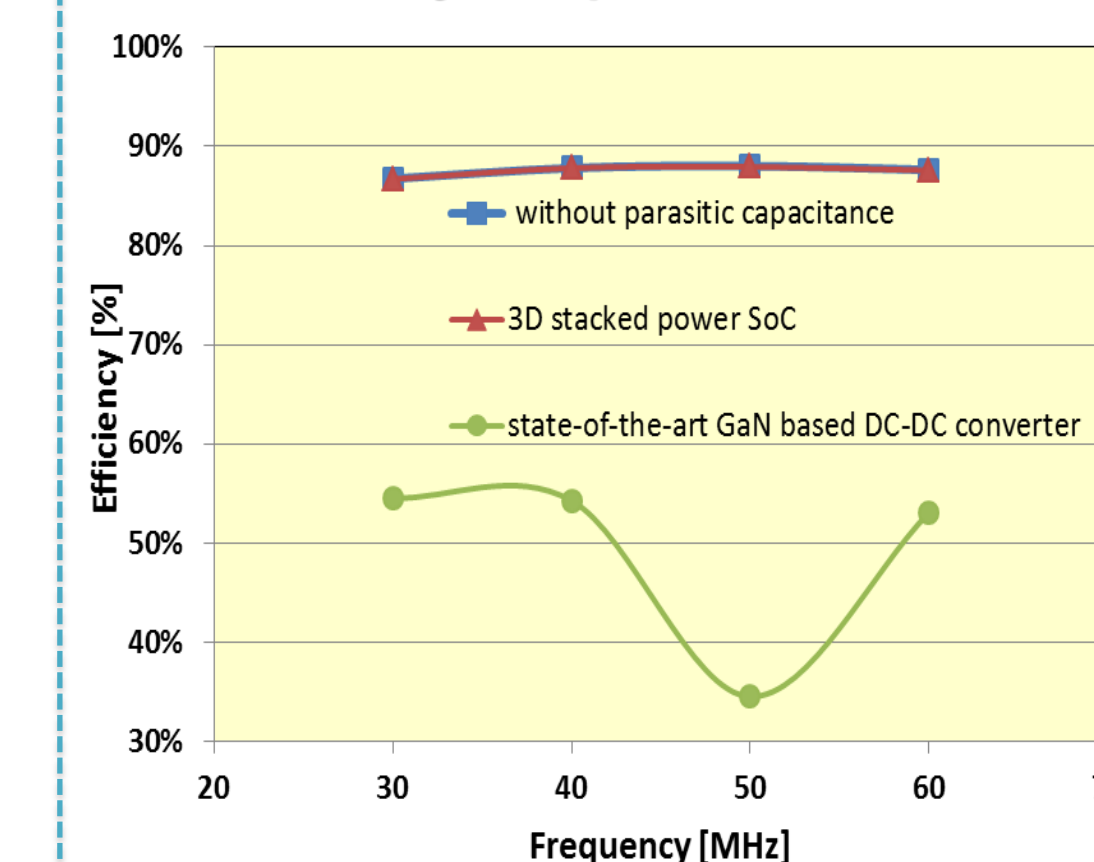
Parasitic model of state-of-the-art GaN based DC-DC converter[1]

	L[nH]	R[mH]
Lpg_1	5.74	2.63
Lpd_1	0.66	0.37
Lps_1	0.12	0.15
Lpg_2	7.53	3.02
Lpd_2	0.20	0.24
Lps_2	0.49	0.20

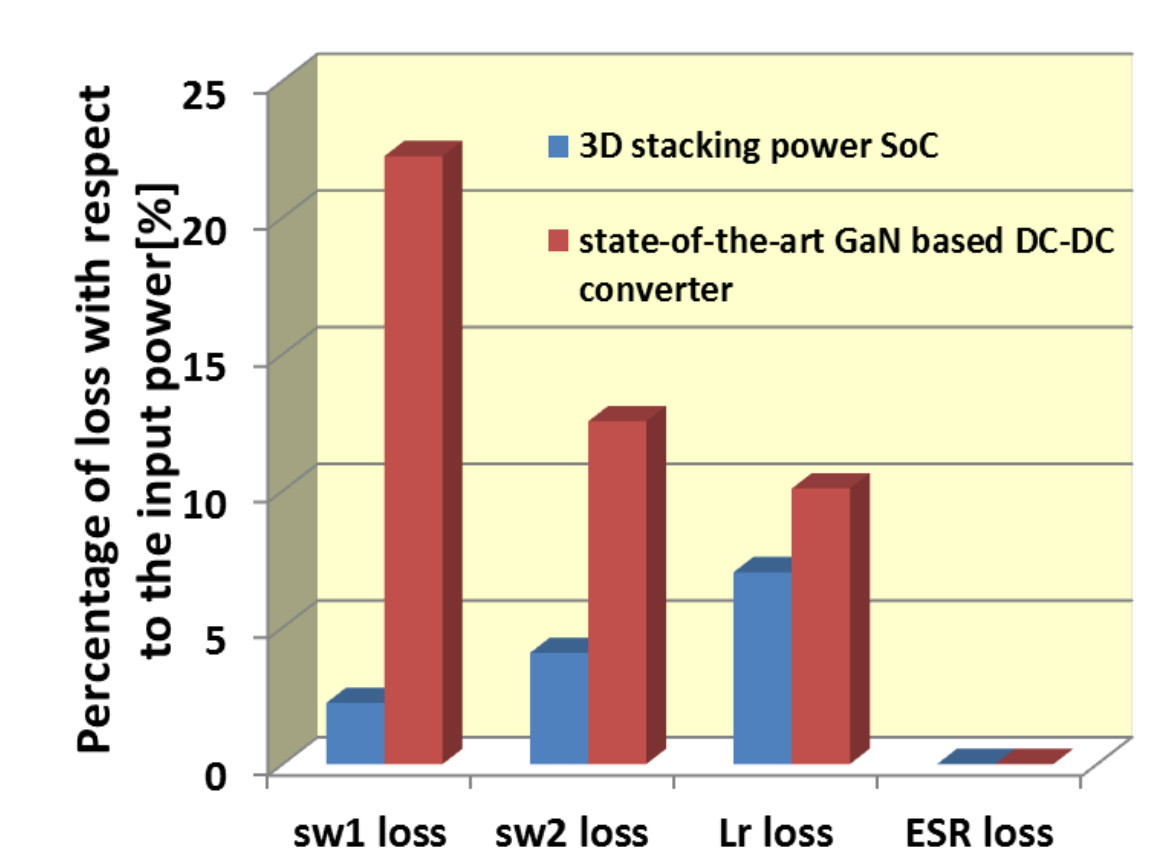
※ 3D power SoC
All parasitic inductance 1 nH
[1] D.C.Reusch, Virginia Polytechnic Institute and State University Doctor thesis, p.192, 2012.

Simulation result

Efficiency comparison of each circuit

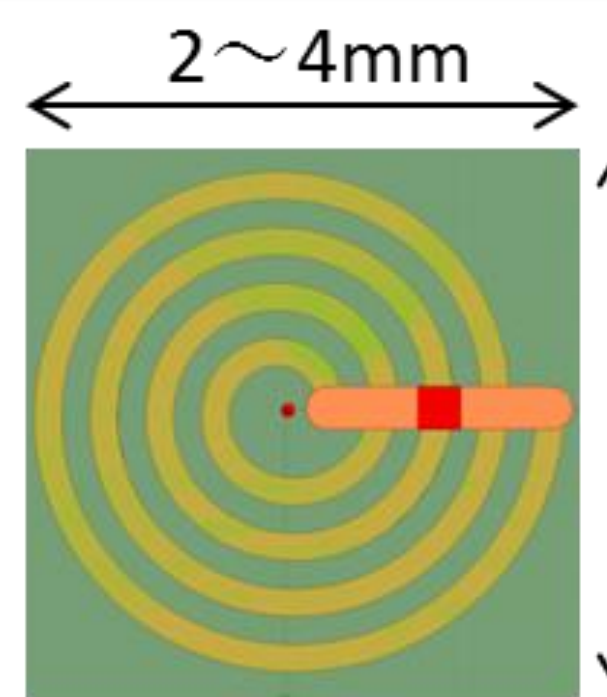


Loss ratio of each circuit



- ✓ Efficiency of the 3D stacked power SoC is always higher than state-of-the-art GaN based DC-DC converter.

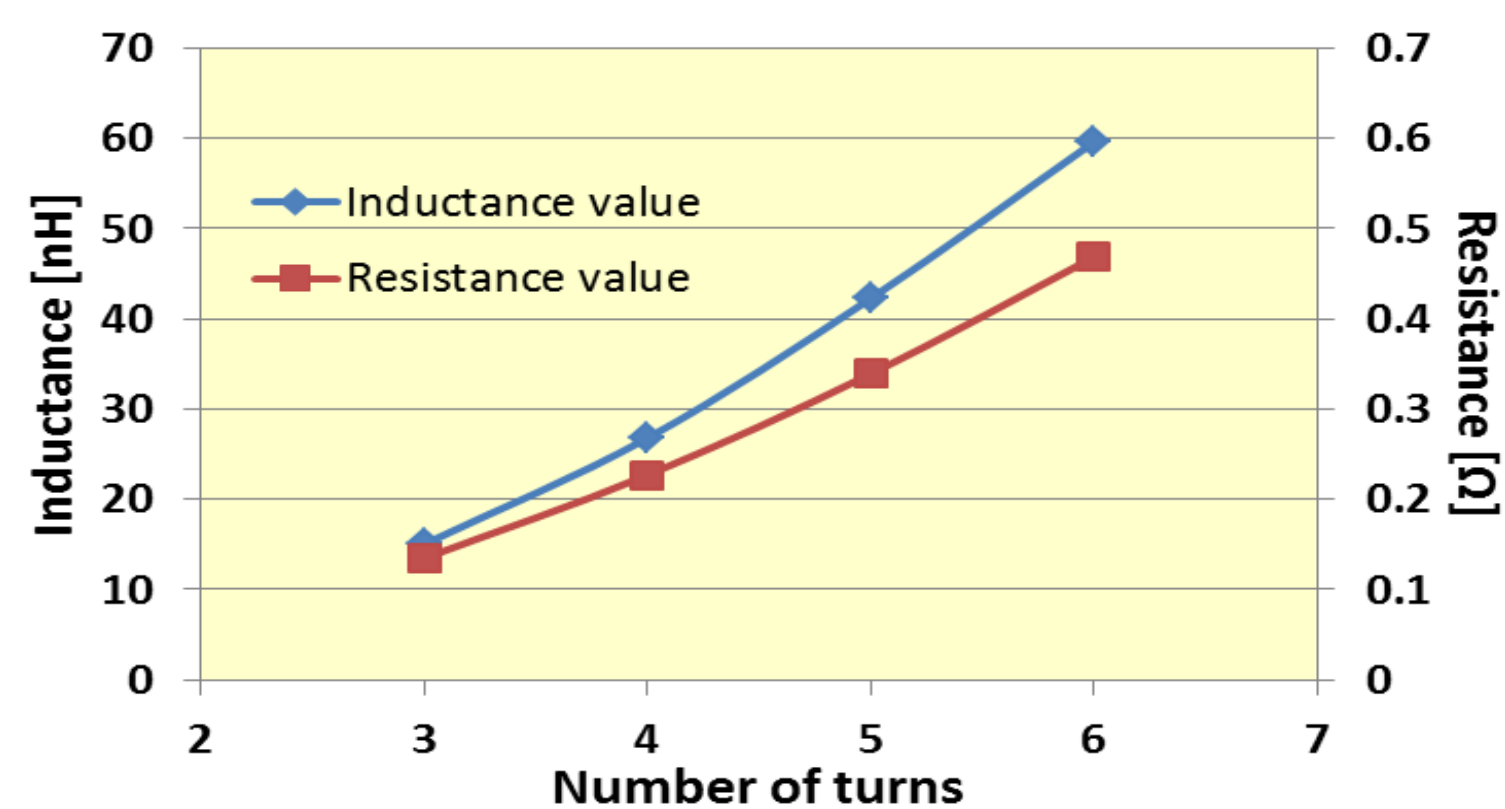
Inductor



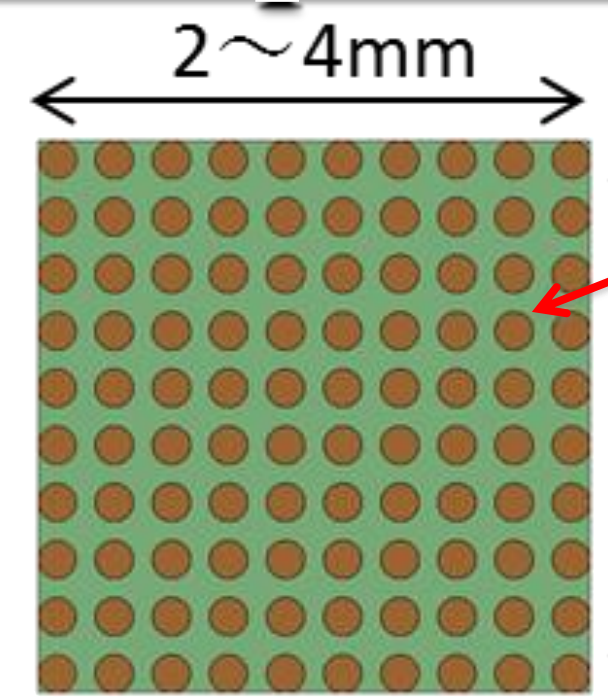
Electromagnetic field simulation

Parameters

- Chip size
- Number of turns
- Line width
- Frequency



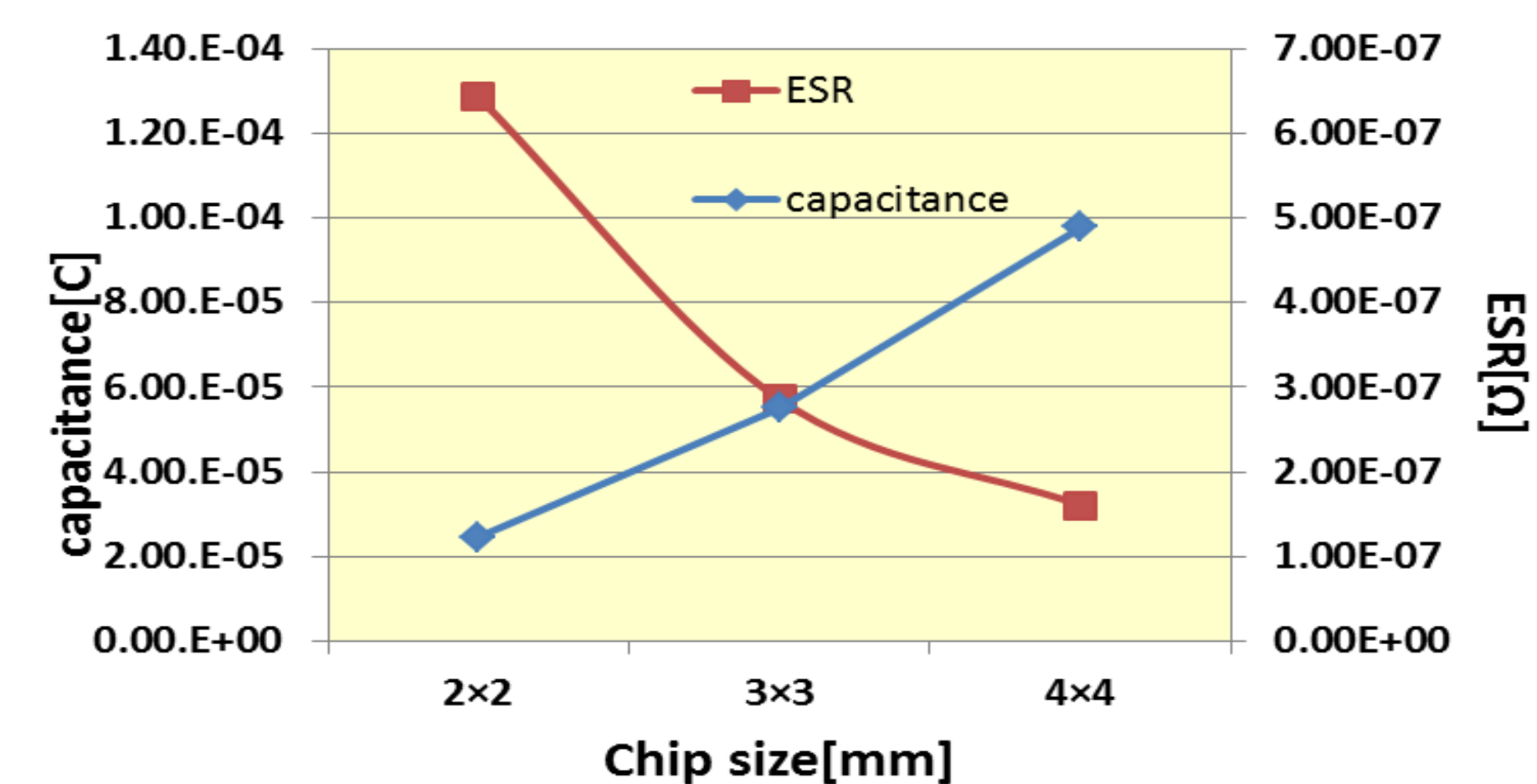
Capacitor



Model analysis

Parameters

- Chip size
- Number of Trench
- The diameter of the trench
- The depth of the trench



Conclusion

- ✓ We clarify the potential of 3D stacked power supply on chip and its impact for high frequency DC-DC converter.
- ✓ The efficiency of the 3D stacked power SoC is always higher than state-of-the-art GaN based DC-DC converter.