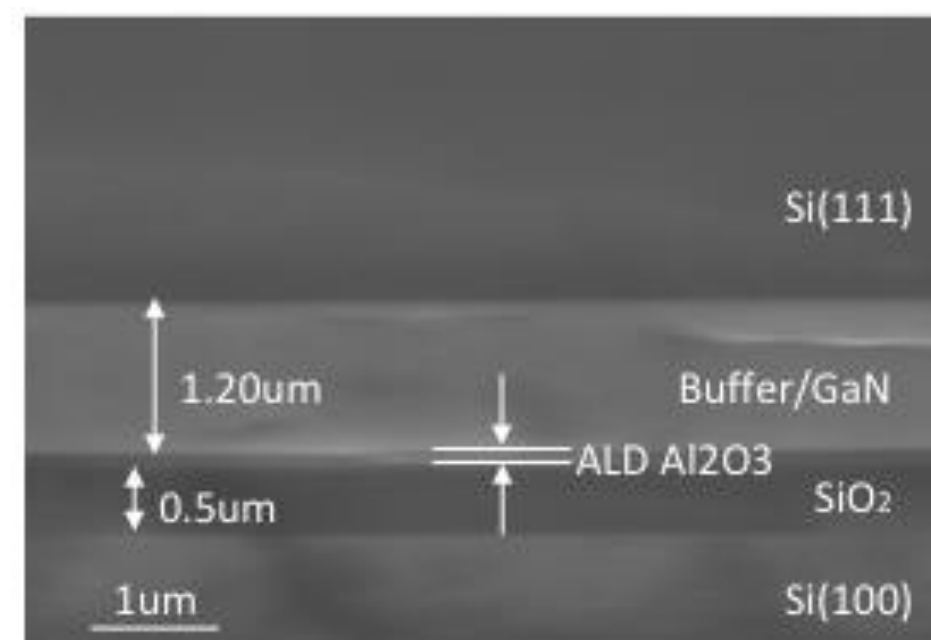


## INTRODUCTION

### ➤ Advantages of 3D Power SoC

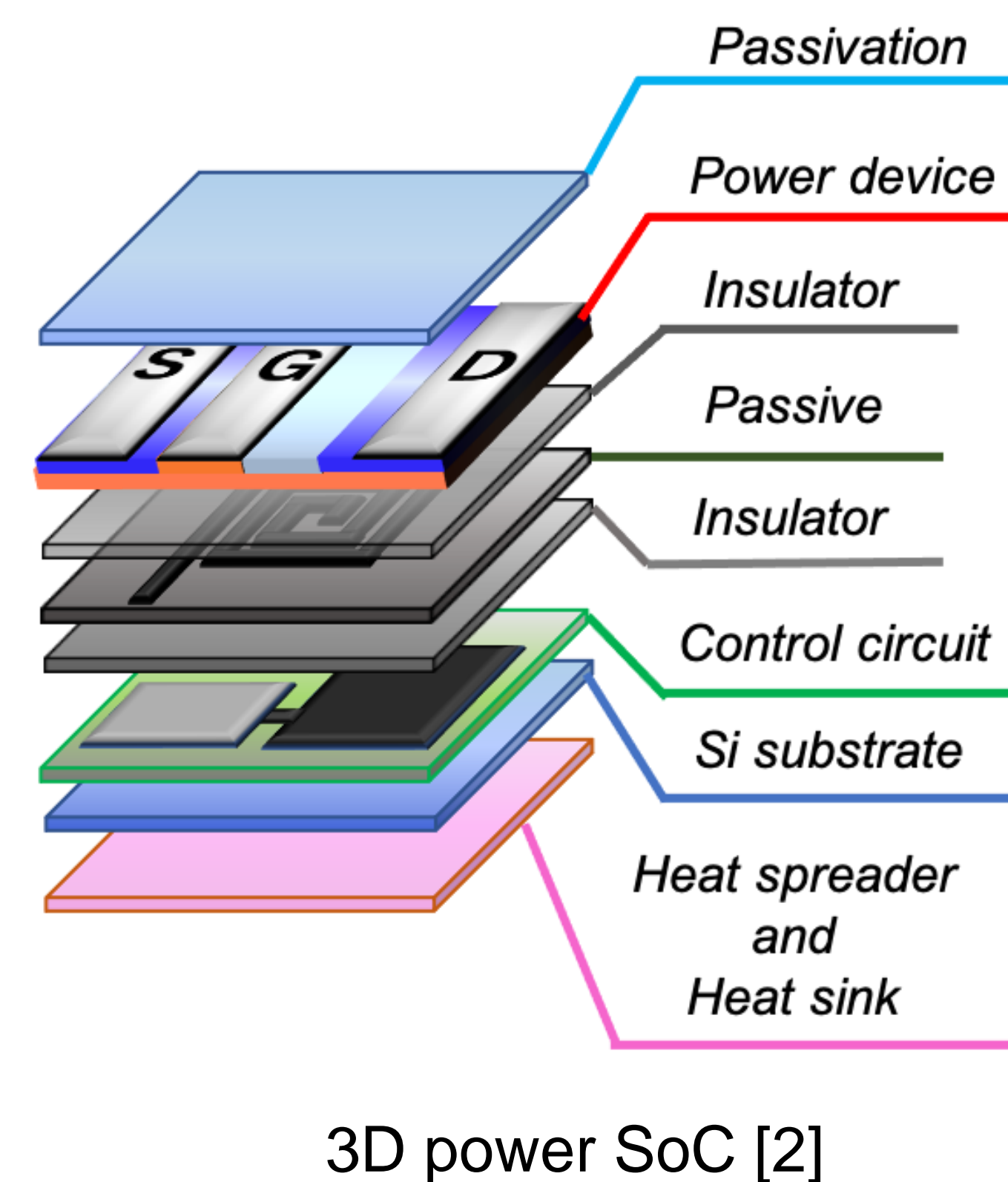
- High efficiency at high frequency switching
- High power density (miniaturization)



Direct bonding of GaN - Si(100) [1]

### ➤ Challenges

- Heterogenous integration
- **Heat removal**
- **Electromagnetic noise shielding**



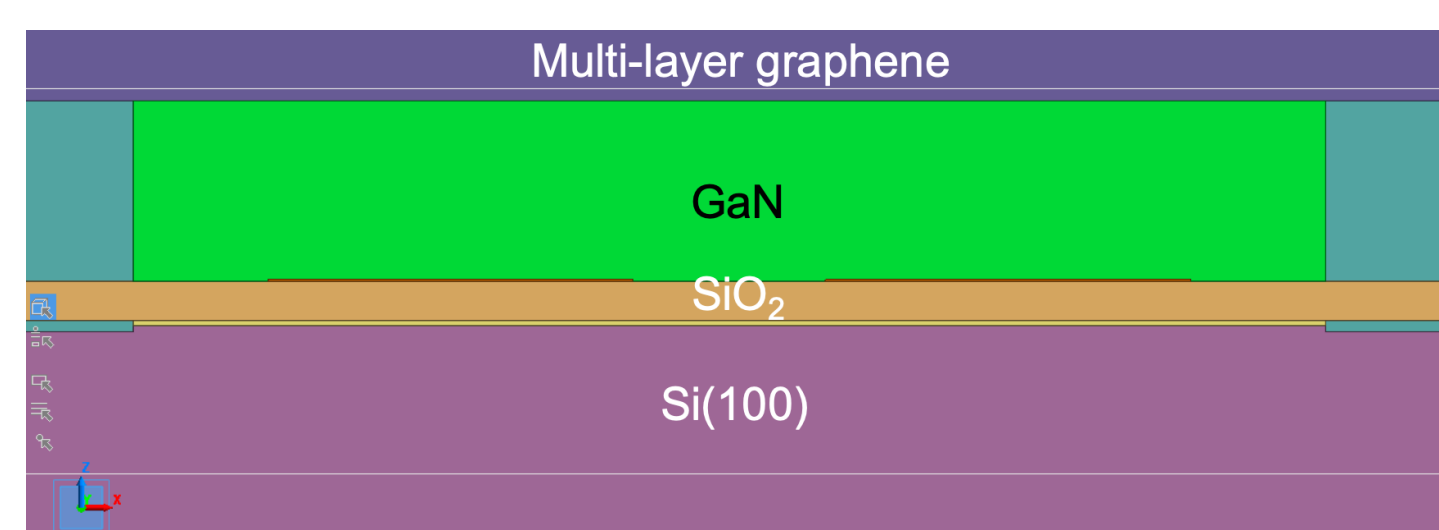
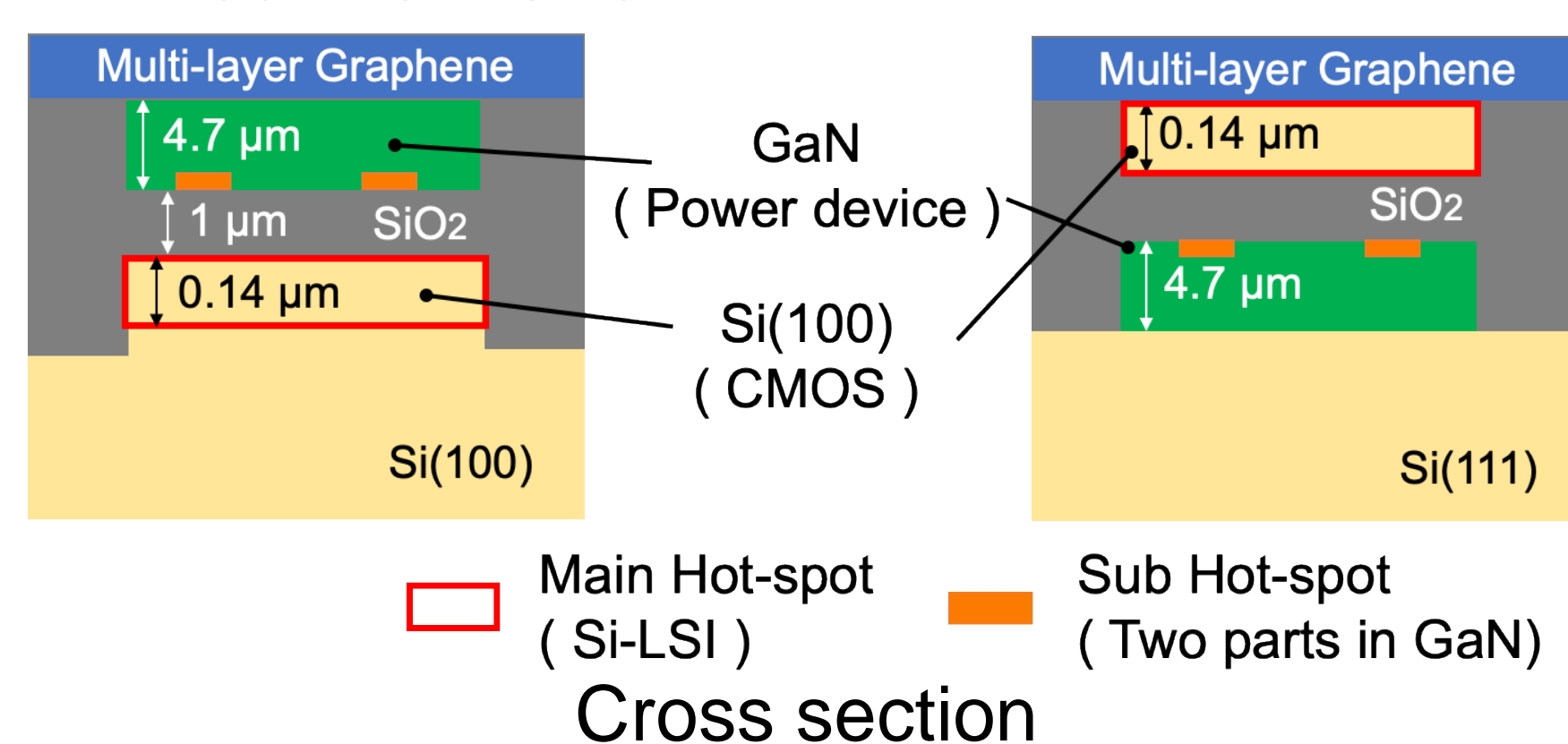
## Multi-layer graphene

[1] R. Ishito, K. Ono, and S. Matsumoto, IEEE CPMT Symposium Japan 2019, ECR Session 12, 2019.

[2] K. Hiura, Y. Ikeda, Y. Hino, and S. Matsumoto, Japanese J Applied Physics, vo.56, 04CR13, 2017.

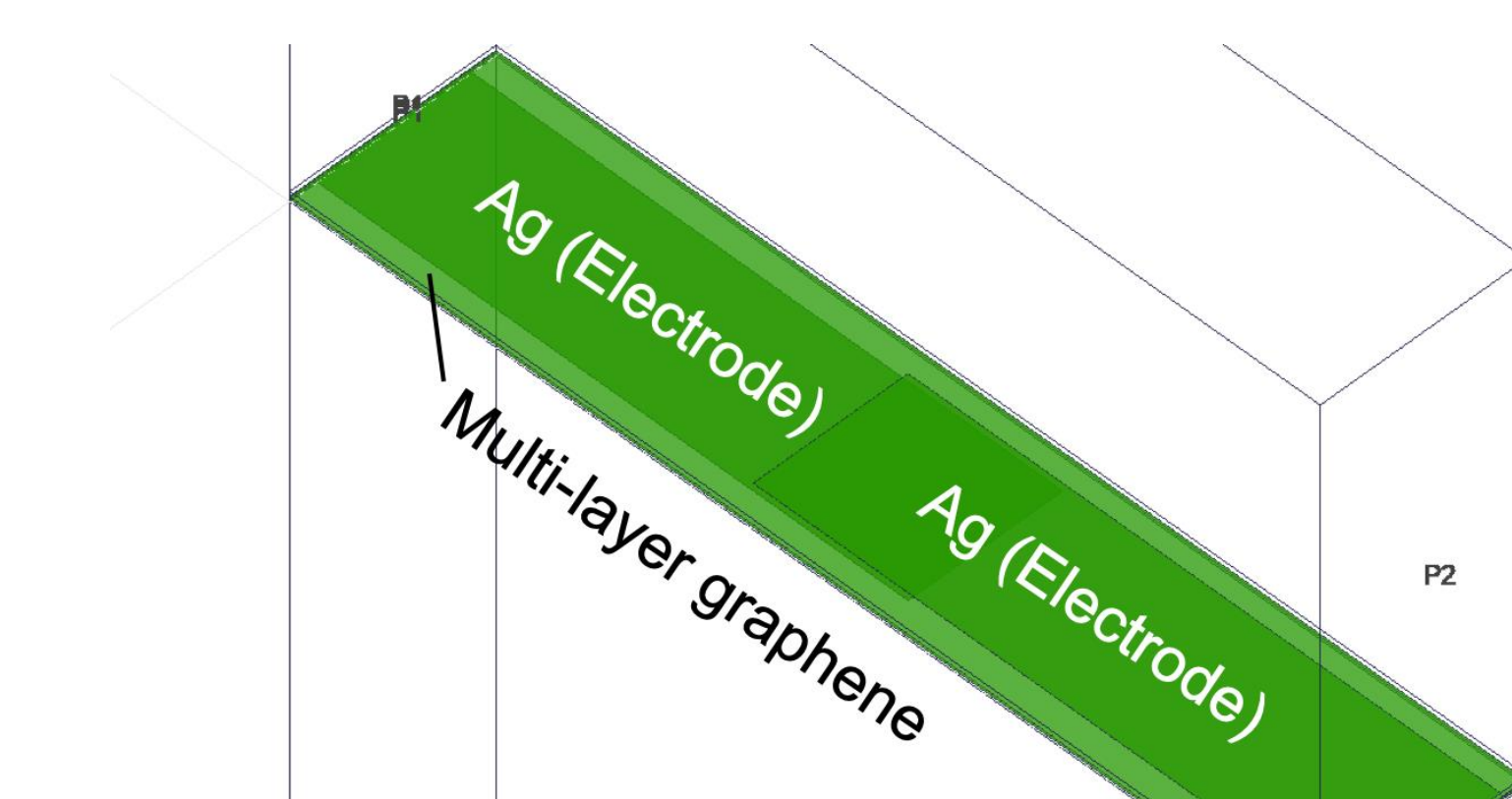
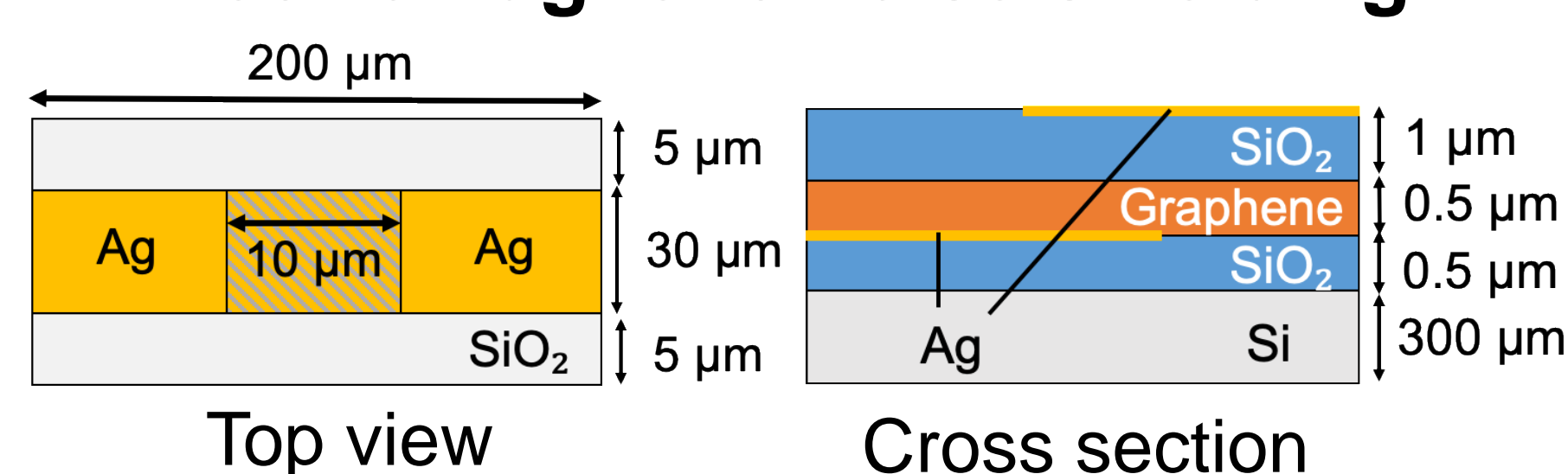
## DESIGN DETAILS

### ➤ Heat removal



Structure at thermal-fluid simulation

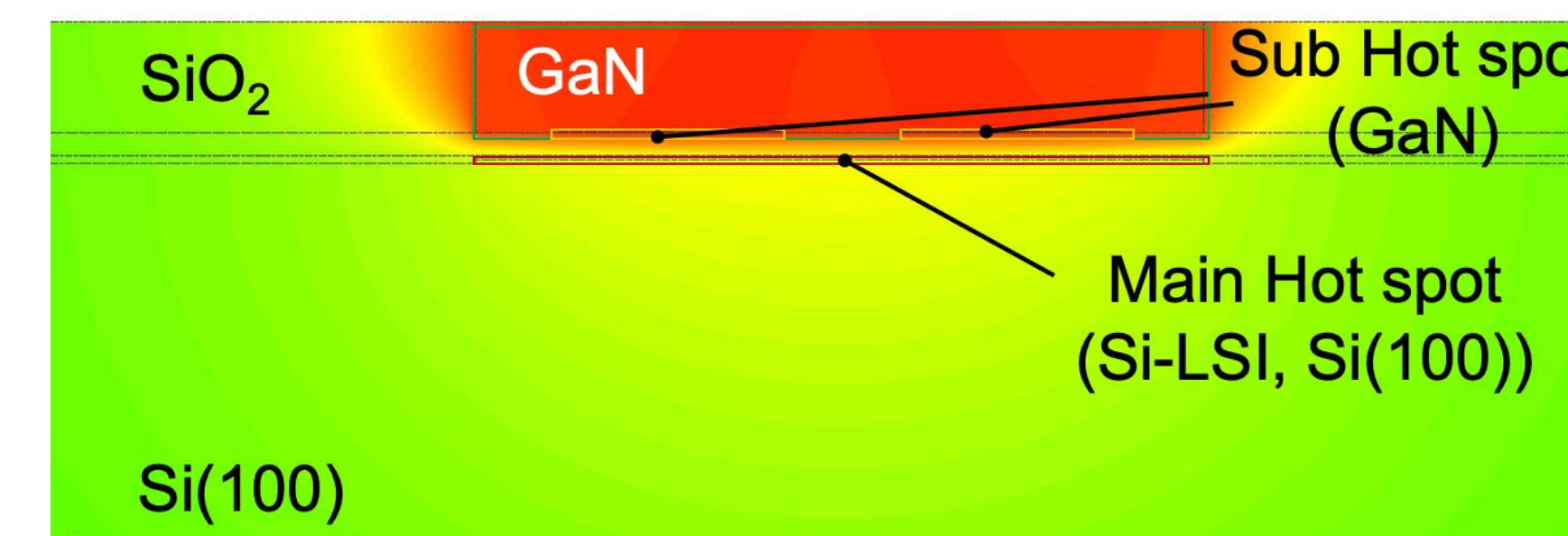
### ➤ Electromagnetic noise shielding



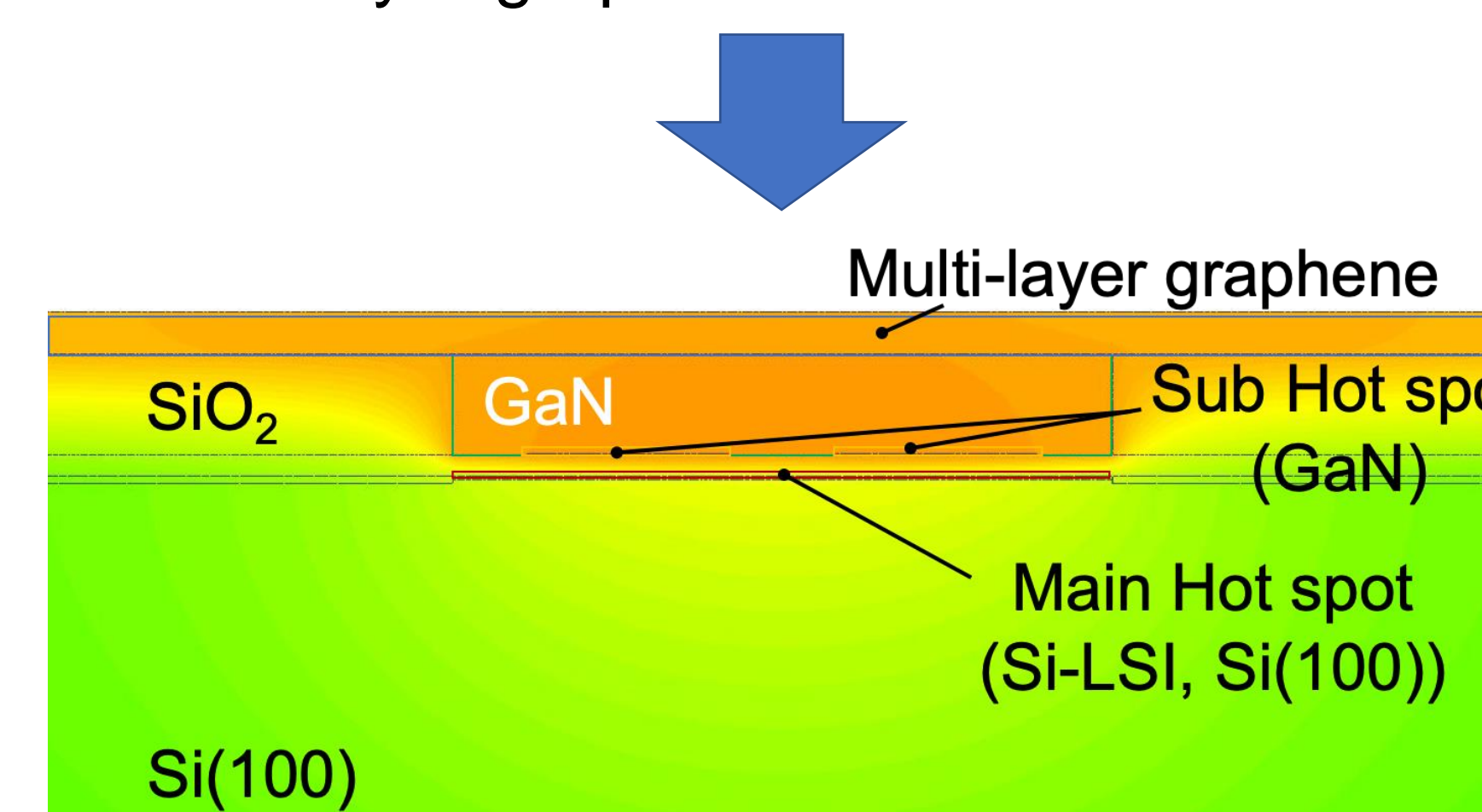
Structure at elector-magnetic field simulation

## SIMULATION RESULTS

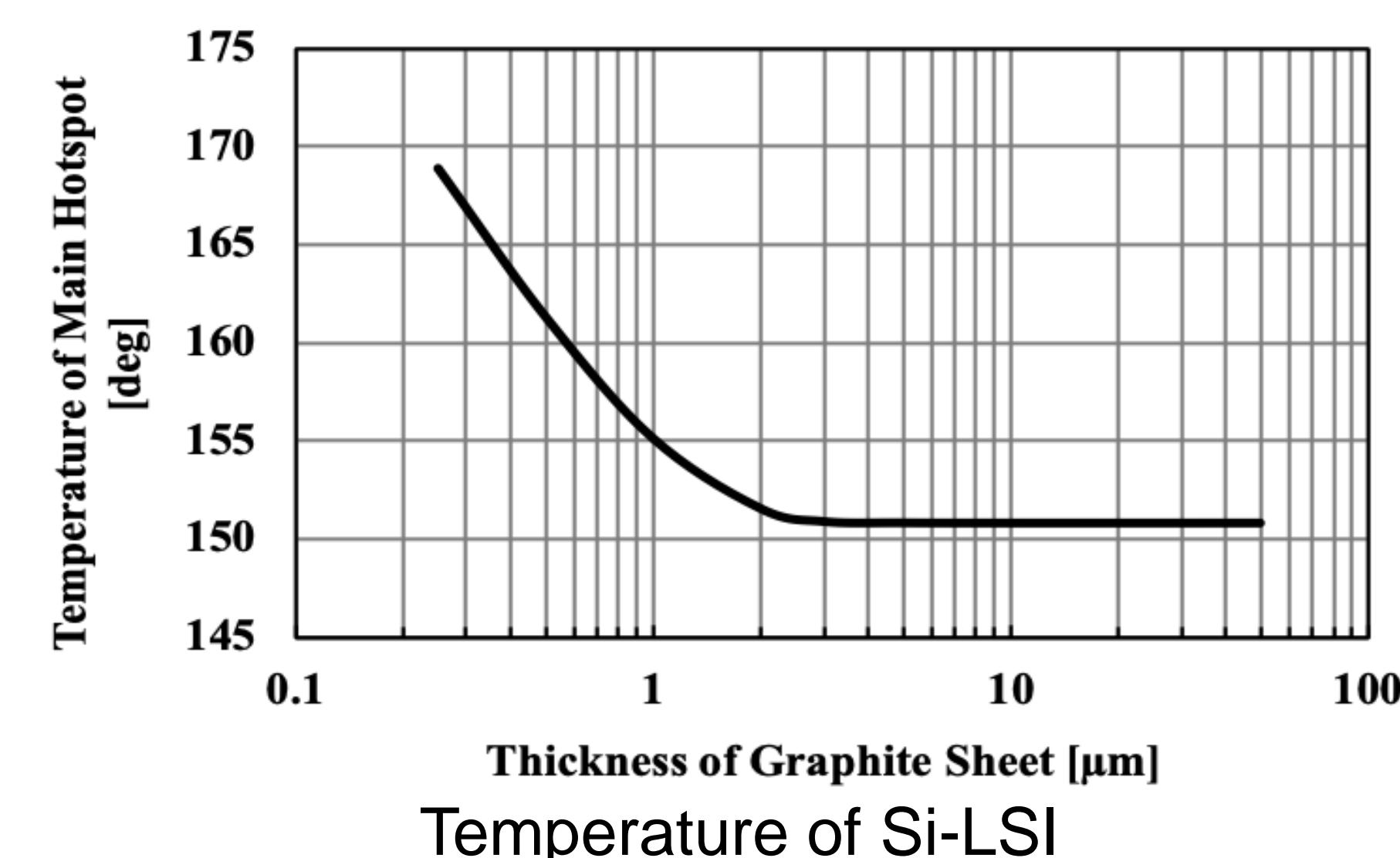
### ➤ Heat removal



- ✓ Temperature of GaN is 192 deg without multi-layer graphene.

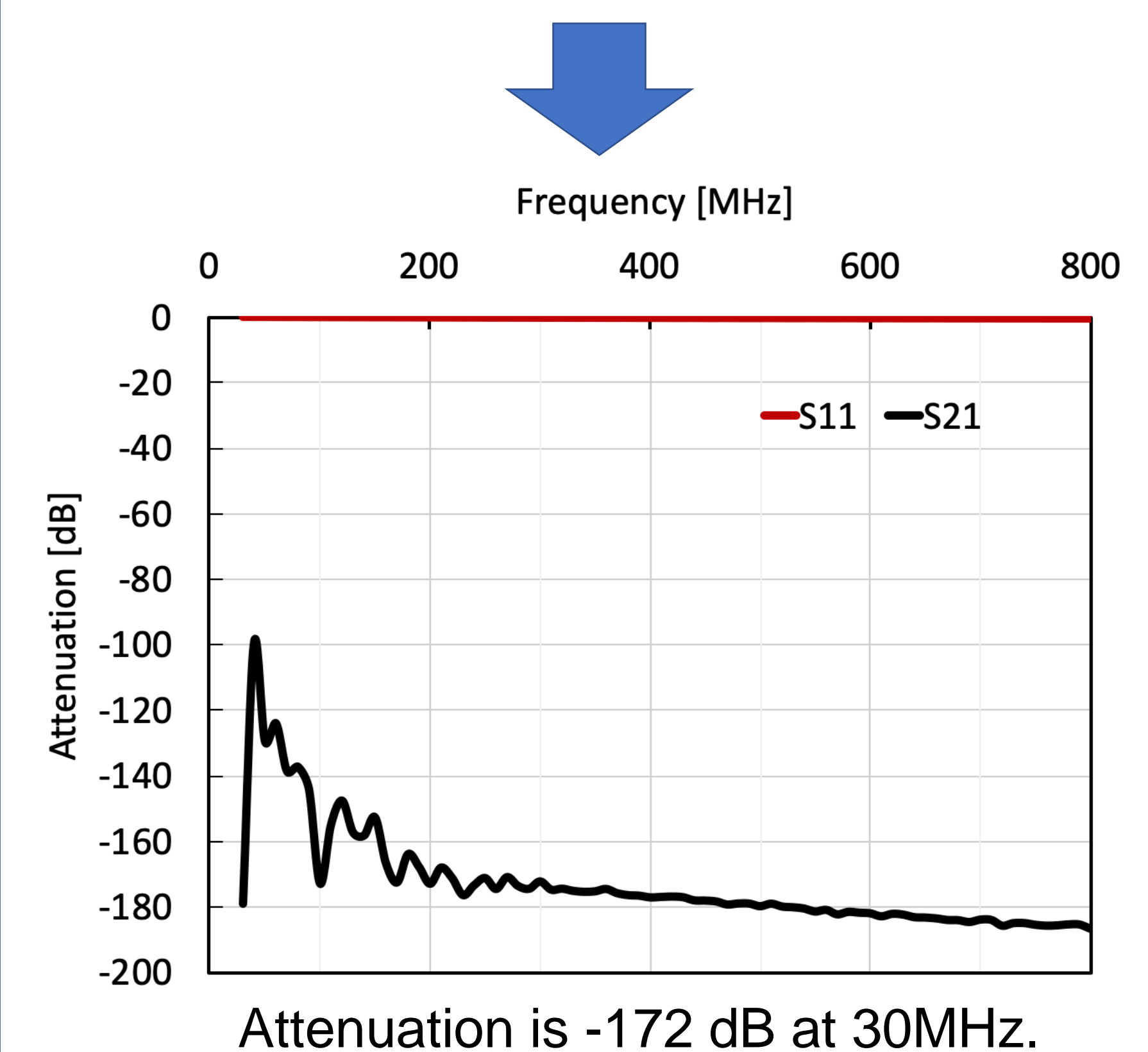
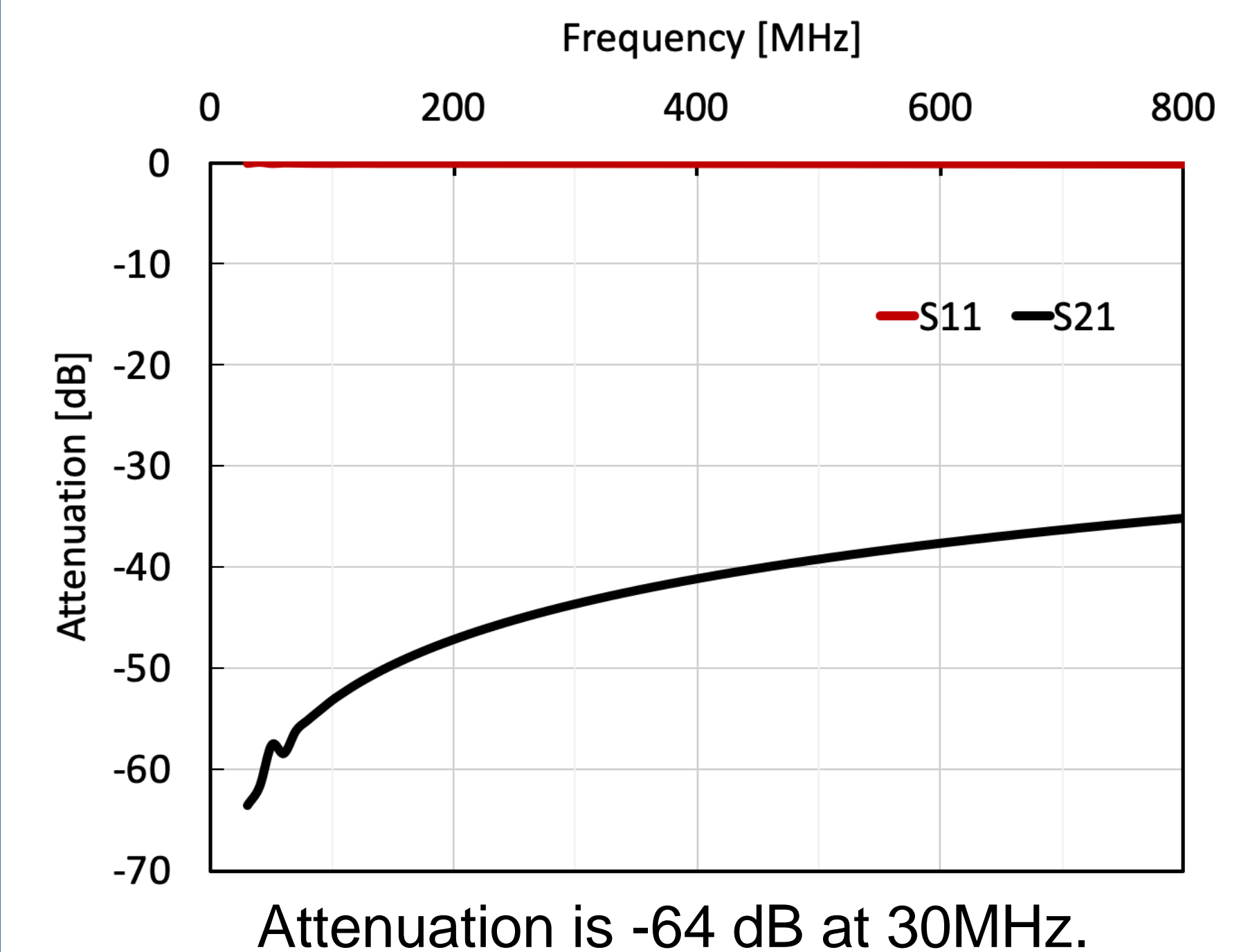


- ✓ Temperature of GaN is 174 deg with multi-layer graphene.



- ✓ Thickness of graphene needs more than 2um.

### ➤ Electromagnetic noise shielding



- ✓ Noise attenuation with multi-layer graphene is 108 dB higher than without it.

## SUMMARY

- ✓ We can remove the heat of hot-spot in GaN power device by putting GaN on Si-LSI and using multi-layer graphene.
- ✓ Multi-layer graphene enables to shield electromagnetic noise.

## ACKNOWLEDGEMENTS / CONTACT

The part of this work was supported by JSPS KAKENHI Grant Number 18H01430.

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