

Chip and Package-Level Wideband EMI Analysis for Mobile DRAM Devices

Jin-Sung Youn (Samsung Electronics)

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SPEAKERS

Jin-Sung Youn

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He received the B.S. degree in Information and Telecommunication Electronics Engineering from Soongsil University, Korea, in 2007. He received He received the M.S. and Ph.D. in Electrical and Electronic Engineering from Yonsei University, Korea, in 2014. His doctoral dissertation concerned the high-speed and power-efficient 850-nm Si optoelectronic integrated receivers for optical interconnect applications. In 2014, he joined the Samsung Electronics, Gyeonggi-do, Korea, where he is currently a Senior Engineer. His current research interests include the area of design methodology that include signal integrity (SI), power integrity (PI), electromagnetic interference (EMI), and electrostatic discharge (ESD).



Agenda

- Background
 - Trends of in Mobile Devices
 - EMI Source in Mobile Devices
- Wideband EMI Analysis Methodology
 - EMI Simulation Flow
 - Chip/Package–Level EMI Solution
- Correlation with Measurement Results
- Conclusion

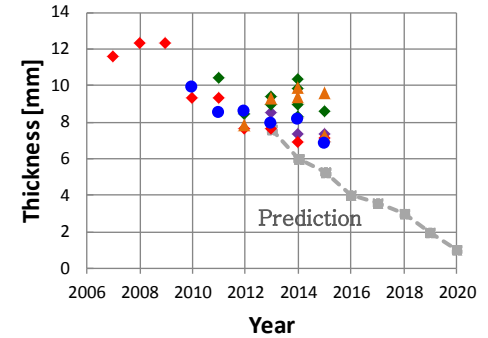
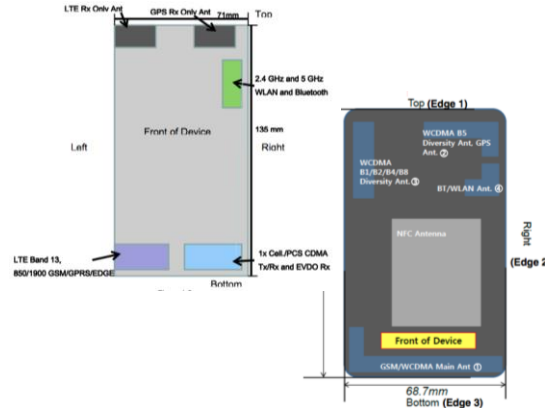


Trends of Mobile Devices

- **High performance/integration:** multi cores, multi functions, huge data processing, ...
 - 800+ components in a mobile device
- **Higher connectivity:** GSM, CDMA, UMTS, LTE, Bluetooth/WiFi, GPS, 5G(28GHz) ...
- **Thin and slim device**



Source: www.samsung.com



Source: www.phonearena.com
www.bizwatch.co.kr

Electromagnetic interference (EMI) becomes a critical issue !



Evaluation of EMI Characteristics

- EMI Issues
 - RF sensitivity degradation: cellular bands (2G/3G/LTE), Bluetooth/WiFi, GPS
 - Malfunctions
 - Display/camera performance degradation
 - Ghost swipe in touch screen panel (TSP)

Set-Level EMI



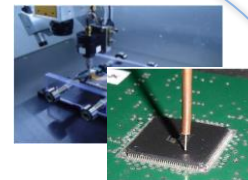
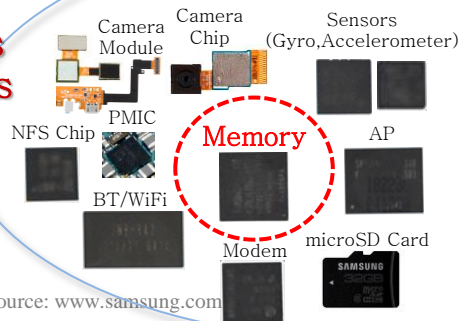
- ▶ Far-Field
- ▶ TIS

* TIS: Total Isotropic Sensitivity

Classify EM Noises
& Find Root Causes



Component-Level EMI



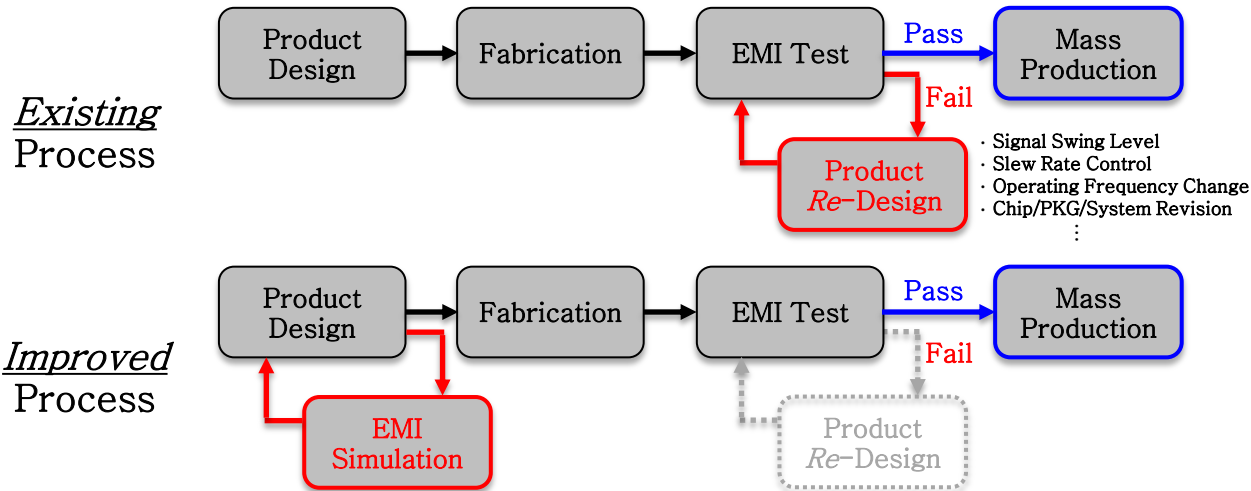
- ▶ Near Field

Near-field scan (NFS)-based EMI analysis is essential !



If Our Products Failed by EMI ...

- Most of EMI evaluation and verification rely on testing ...
 - ➔ Requirement of additional cost and time to fix
- Effort (cost & time) can be reduced by adopting EMI simulation in the product design stage.

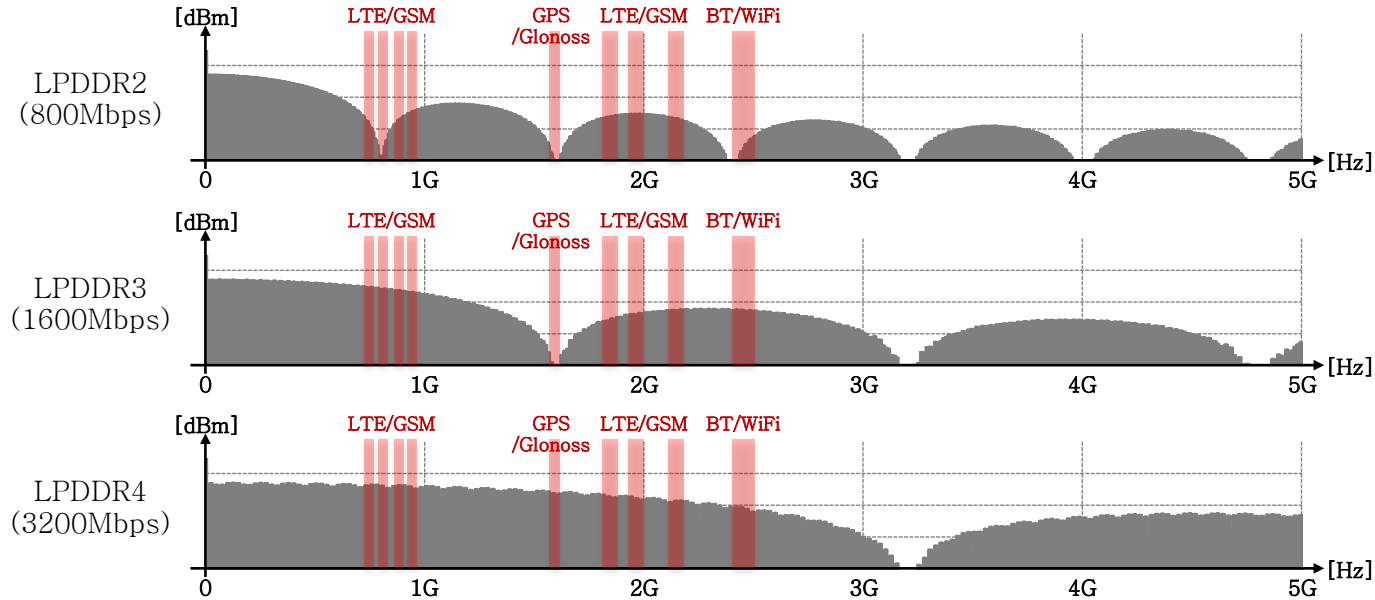


EMI analysis methodologies are strongly required !



Why We Need Wideband EMI Solution ?

- Data rate of mobile DRAMs continuously increases...
 - LPDDR2(800Mbps) → LPDDR3(1600Mbps) → LPDDR4(3200Mbps) → ...

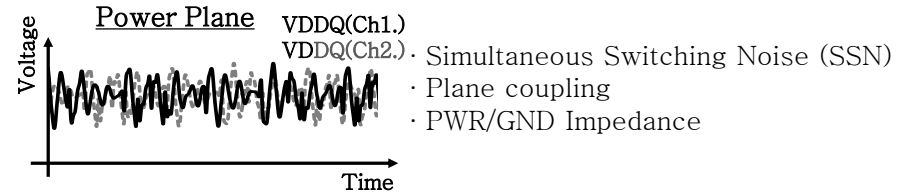
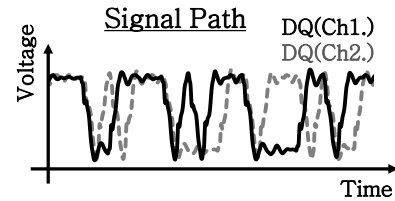
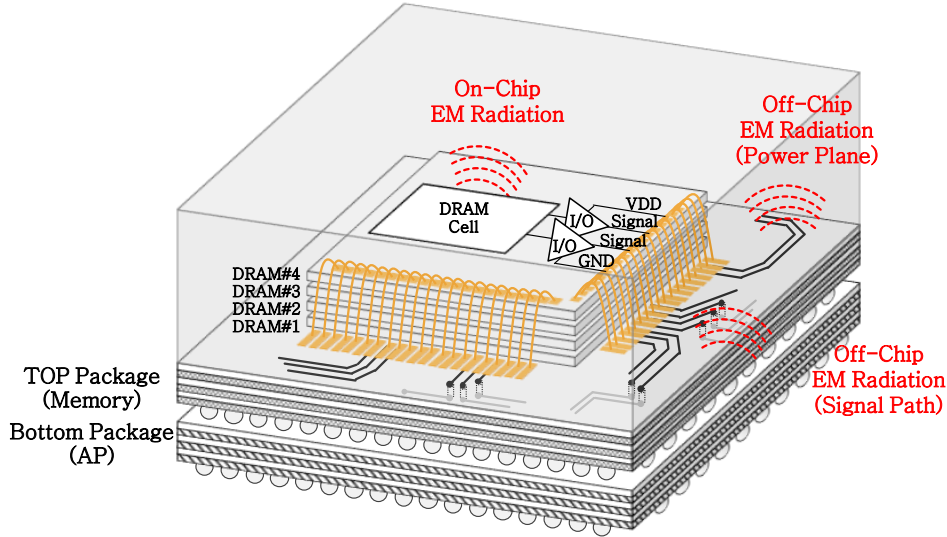


Radio-frequency interference (RFI) between memory and wireless antennas...



EMI Sources in Mobile DRAM Devices

- Package-on-Package (PoP)
- EMI Sources
 - On-Chip radiation: direct emission (by on-chip interconnection) from chip surface
 - Off-Chip radiation: signal conductors and power plane from package

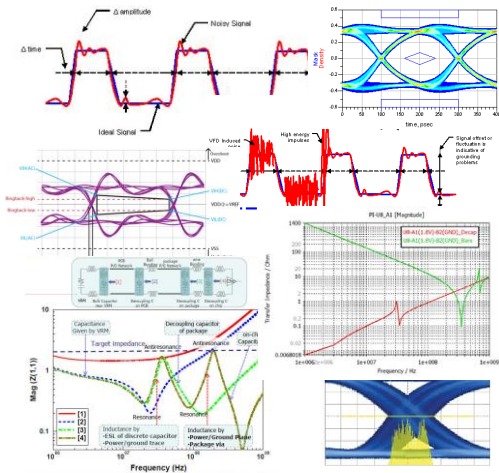


EMI Simulation Flow

- Various circuit/EM simulation tools are available for EMI simulation.
- How to increase accuracy of EMI simulation ...?

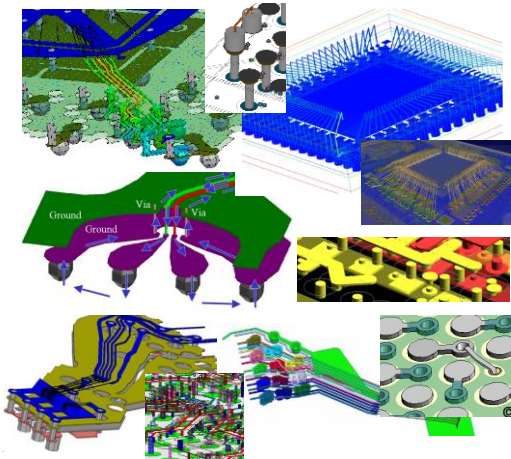
STEP1

EMI Source Extraction



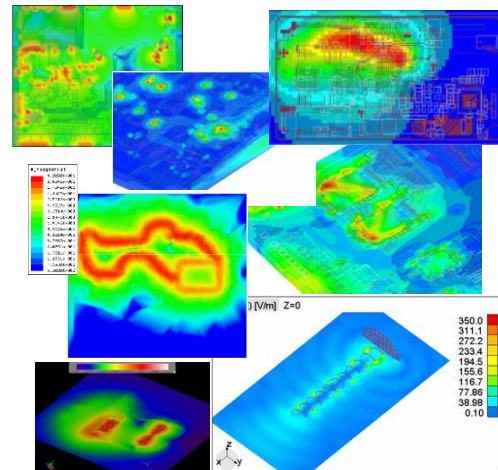
STEP2

Chip/PKG Modeling



STEP3

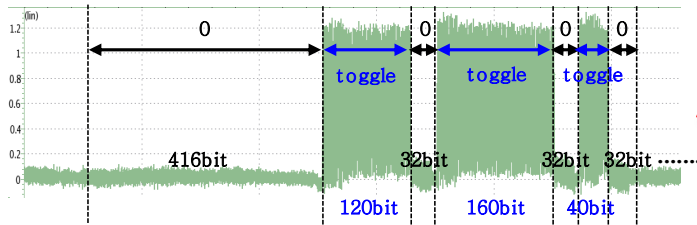
Near-Field Simulation



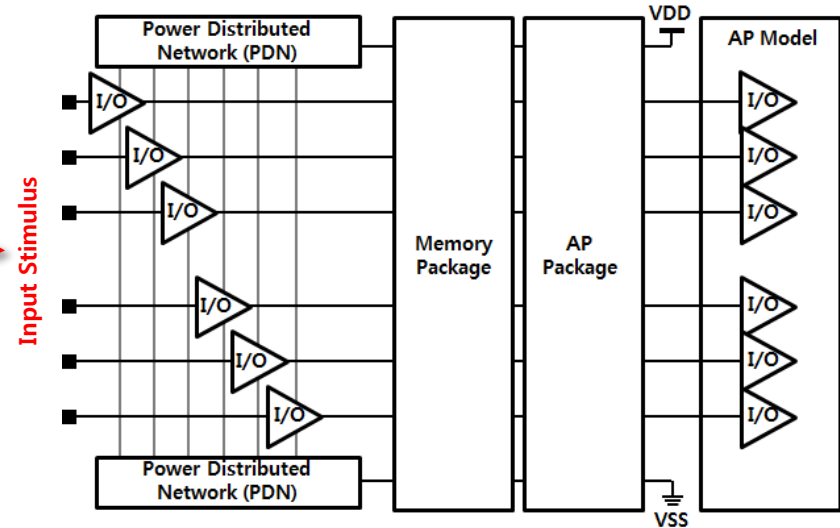
Source: www.google.com

EMI Source Extraction

- Memory read operation at 1.6 Gbps
- Block diagram
 - Memory I/O buffer
 - Power distributed network (PDN)
 - Memory/AP package models
- Input stimulus
 - Verify by package direct probing & logic analyzer
 - Periodic pattern (832bits)



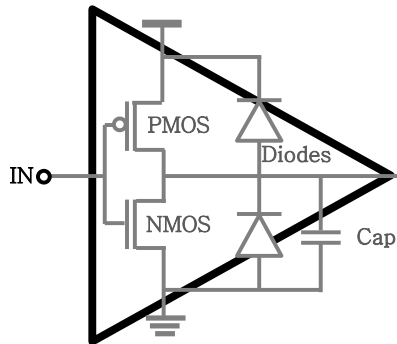
*Toggle: 1010...
Non-Toggle: 0000...



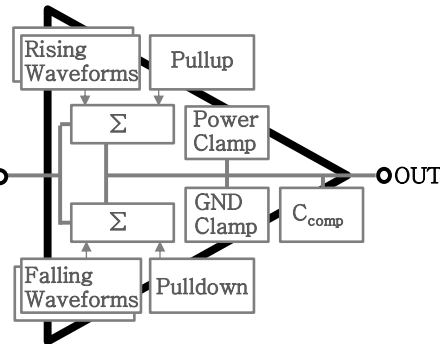
EMI Source Extraction – I/O Buffer Model

- SPICE model provides better accuracy with long simulation time.
- IBIS Model
 - Static and dynamic curves describing electrical behavior of the I/O
 - Used for fast extraction of basic parameters

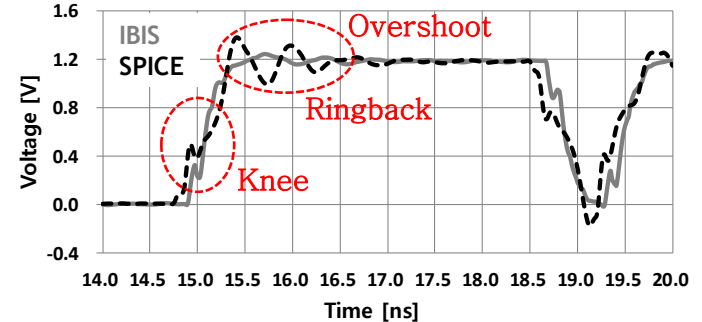
SPICE Model



IBIS Model



* IBIS: I/O Buffer Information Specification



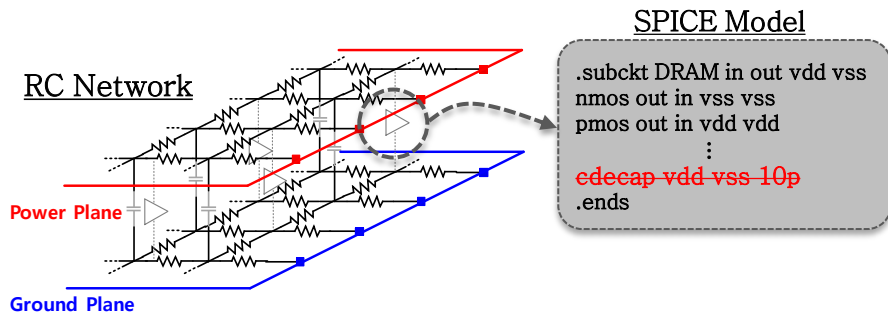
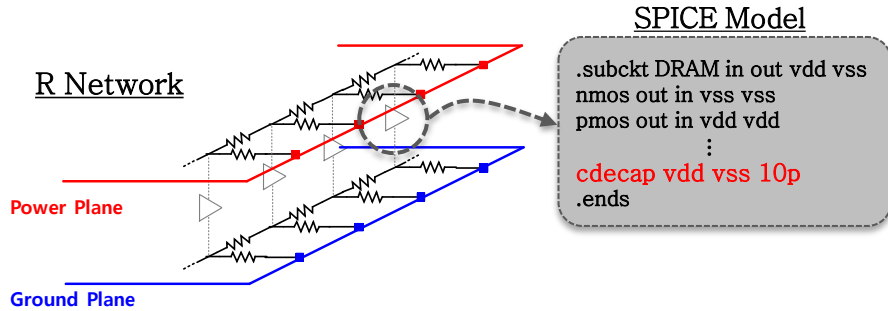
- ✓ Waveform differences btw SPICE and IBIS Models
- ✓ High-frequency components

➔ SPICE model is needed to achieve wideband EMI solution.

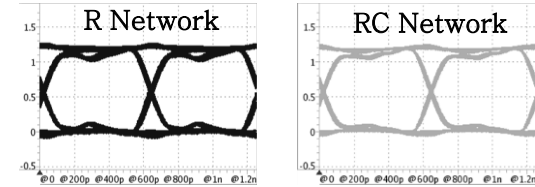


EMI Source Extraction – Power Distributed Network (PDN)

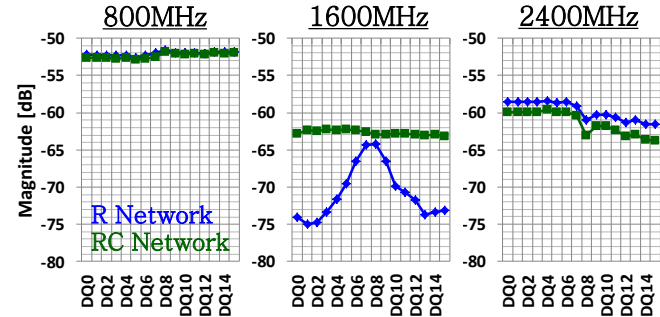
- PDN based on R-network can be used for simple and fast simulation.
- RC Network is extracted from layout → **Accurate PDN effect can be included in our simulation.**



▷ Time Domain → No significant difference!

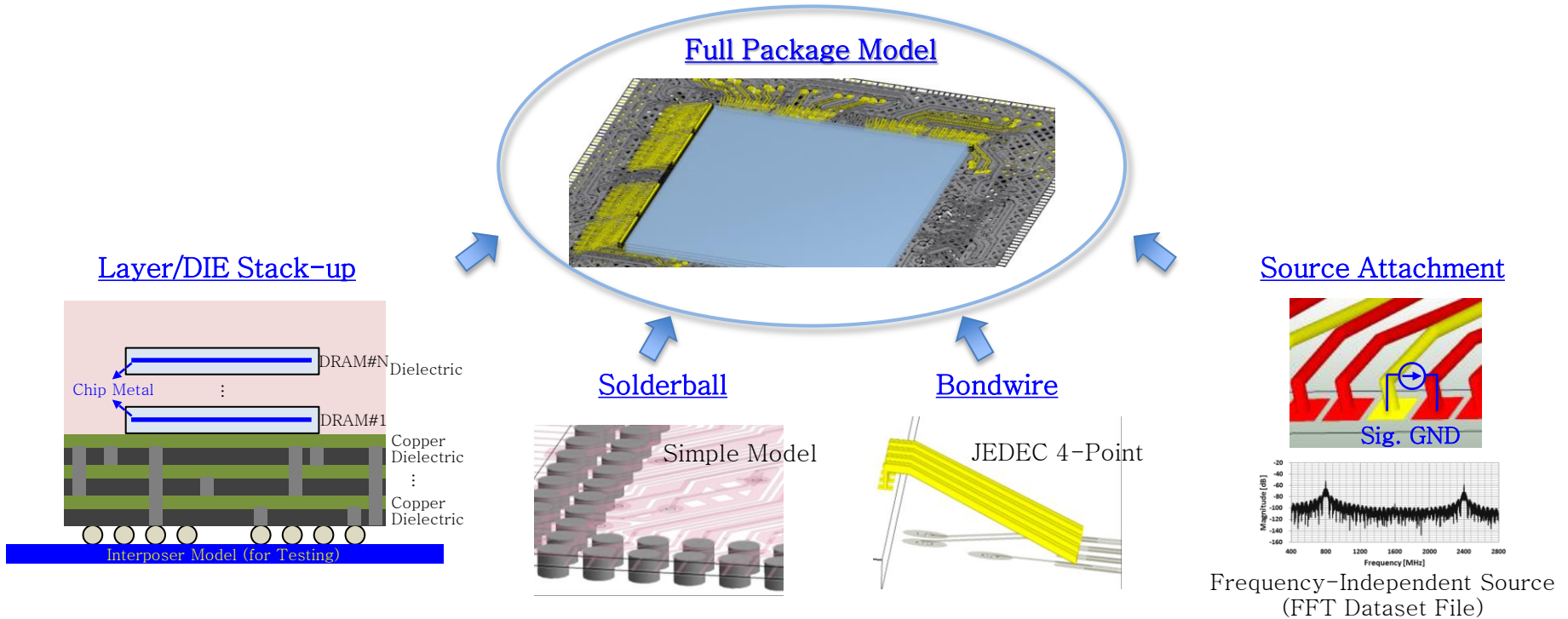


▷ Frequency Domain → ~13dB difference@2nd harmonic



Chip/Package Modeling

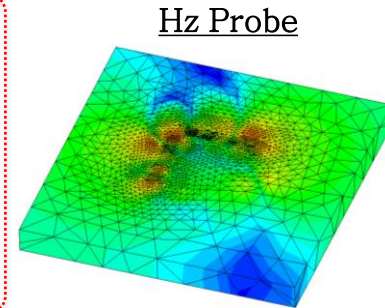
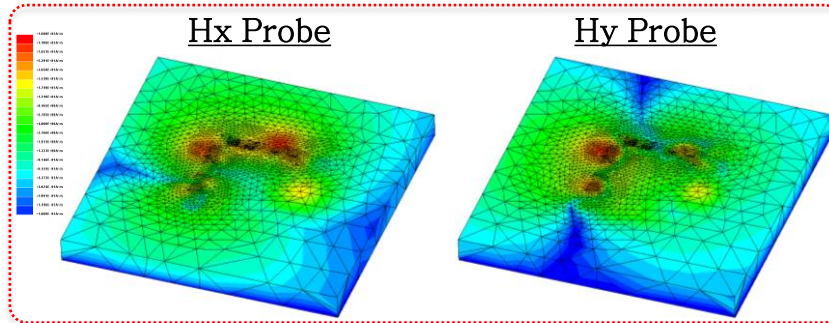
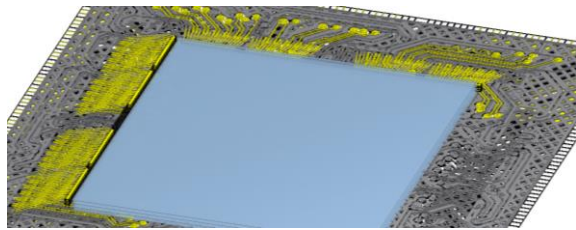
- Package model setting using SIwave



Near-Field Simulation

- Simulation is done using SIwave
- Frequency range
 - 700MHz~1GHz (501points)
 - 1500MHz~1800MHz (501points)
 - 2300MHz~2500MHz (501points)

[Simulation Results at 800MHz]

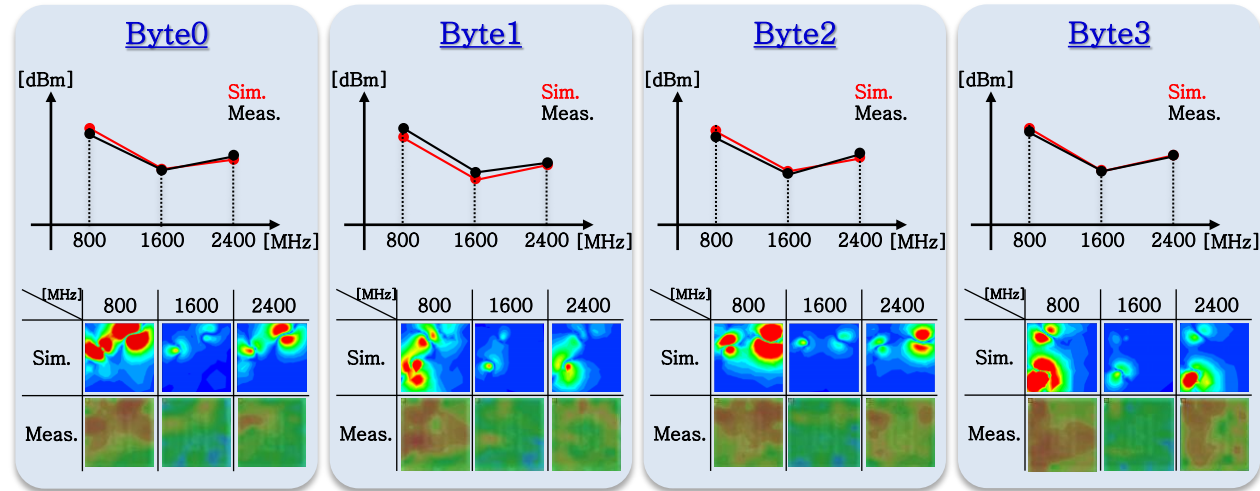
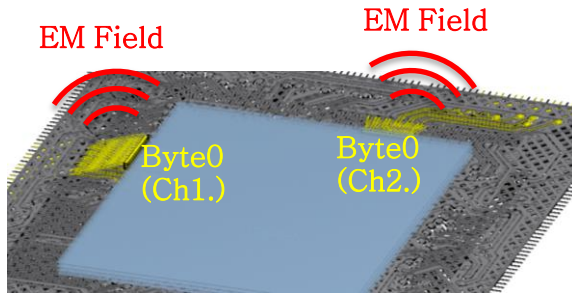


Extract the maximum value btw Hx and Hy probes at each frequency

Correlation (1): Simulation vs. Measurement

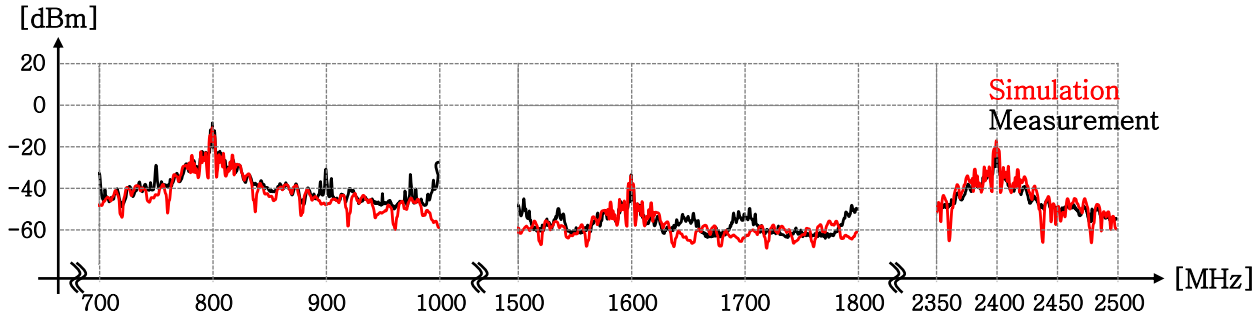
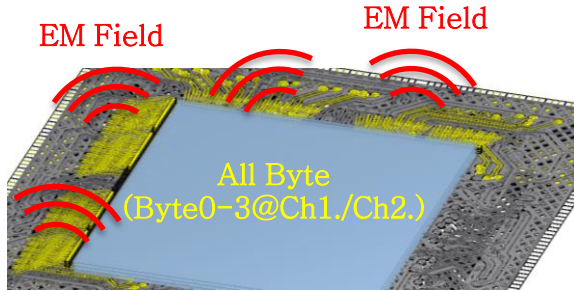
- Memory read operation (1600Mbps) for each byte
- Near-field scan measurement up to 3rd harmonic (800MHz, 1600MHz, 2400MHz)
- Error between measurement and simulation is less than 3dB

Simulation is well matched with measurement !!



Correlation (2): Simulation vs. Measurement

- Memory read operation (1600Mbps) with all byte simultaneously
- Near-field scan (NFS) measurement up to ~2.4GHz
- Correlation between measurement and simulation is about 89.4%



Conclusion

- Wideband EMI Analysis Methodology for Mobile DRAM Devices
- Chip/Package-Level EMI Solution and its Detail Analysis Strategies
 - I/O and Power Distribution Network Models
 - Chip/Package Modeling
- Correlation with Near-Field Scan Measurement Results
 - Wideband spectrum (~ 2.4 GHz) with correlation factor of 89.4 %



Thank you!

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QUESTIONS?

