

# Simulation and Design of Printed Circuit Boards Utilizing Novel Embedded Capacitance Material

April 28, 2010

Yu Xuequan, Yanhang, Zhang Gezi, Wang Haisan  
Huawei Technologies CO., LTD.  
Shanghai, China  
Tony\_yu@huawei.com



**emc 2010**  
**Navigating EMC**

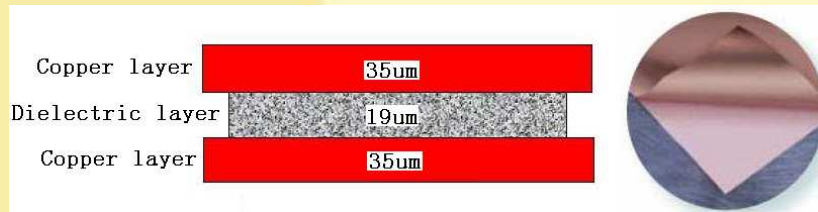


# Outline

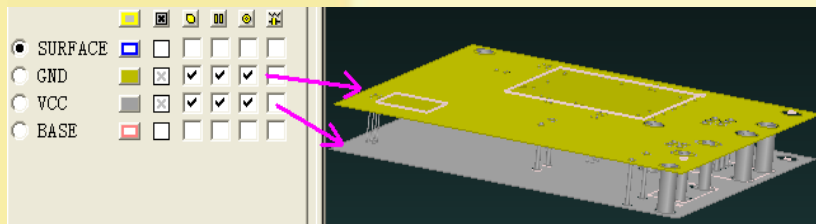
- *Embedded Capacitance Material Introduction*
- *Impedance Simulation Comparison for boards with ECM or FR-4 Power/Ground Core*
- *Comparison of the power noise measurement*
- *In Board Interference Analysis for ECM and FR4 Board*
- *ECM Impact to Signal Integrity*
- *Board Level EMC Performance Comparison – Simulation*
- *Board Level EMC Performance Comparison – Test Result*
- *The Application Prospect of the Embedded Capacitance Materials*
- *Questions*

# Embedded Capacitance Material Introduction

- Planar sandwich structure ECM
- Higher capacitance density than thin core FR4
- Higher decoupling bandwidth than discrete MLCC caps
- 3M C-PLY19
  - 19um filled insulation
  - >6nf/sq inch C/A



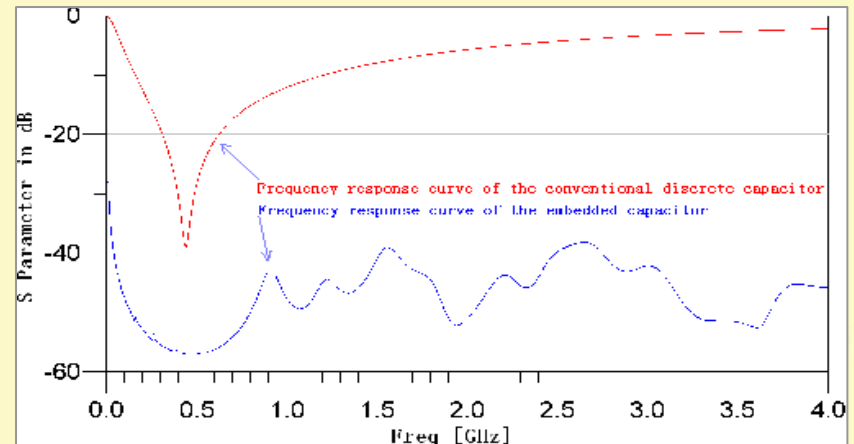
Schematic illustration of 3M C-PLY19



Schematic illustration of PCB plate capacitor

Materials name	FR-4	3M C-PLY19
Parameters	(PCB plate capacitor)	(Embedded capacitor)
Composite	FR-4	Epoxy/Ceramic filler
Dielectric constant (DK)	≈4.0~4.5	21
Dielectric consumption (DF)@1GHz	≈0.02	0.03
Dielectric thickness (um)	≥ 68	19
Capacitance density (nF /inch <sup>2</sup> )	≤0.3	6.2

Electrical parameters comparison  
FR4 plate capacitance vs ECM (3M C-PLY19)



Frequency response comparison , MLCC vs ECM

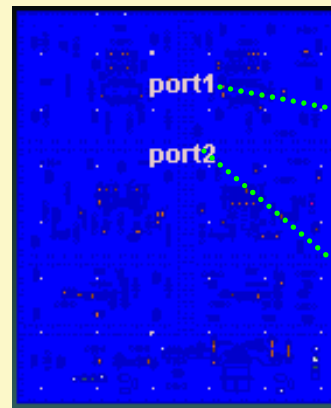


# Impedance Simulation Comparison for boards with ECM or FR-4 Power/Ground Core

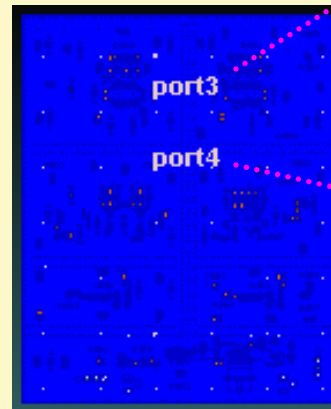
- Same board stack up and layout
- Only difference in Pwr/Gnd core material
- Impedance port set on same position in simulation
- Much lower impedance of ECM from 10MHz~6GHz than FR4
- Much more resonance in FR4 curve, higher impedance and power noise

Layer name	Layout figures	Layout explanation
L1		TOP (GND)
L2	pp(FR4)	SIGNAL
L3	core(FR4)	POWER
L4	pp(FR4) or 3M c-ply19	GND
L5	core(FR4)	SIGNAL
L6	pp(FR4)	BOTTOM (GND)

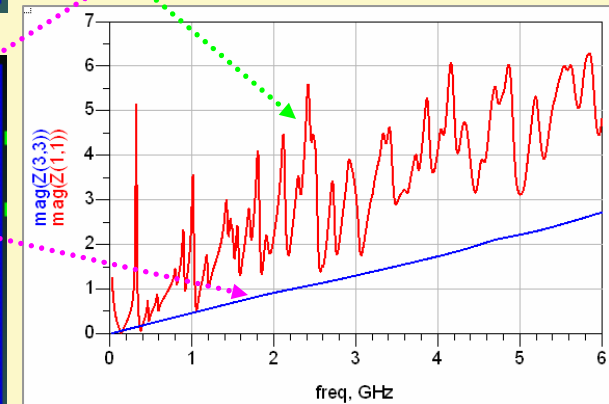
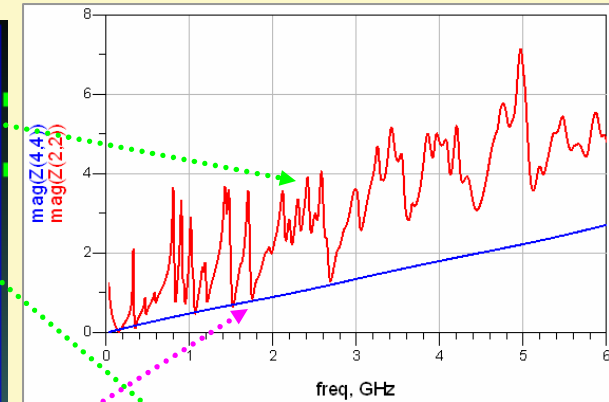
Sample board Stack up



FR-4 PCB



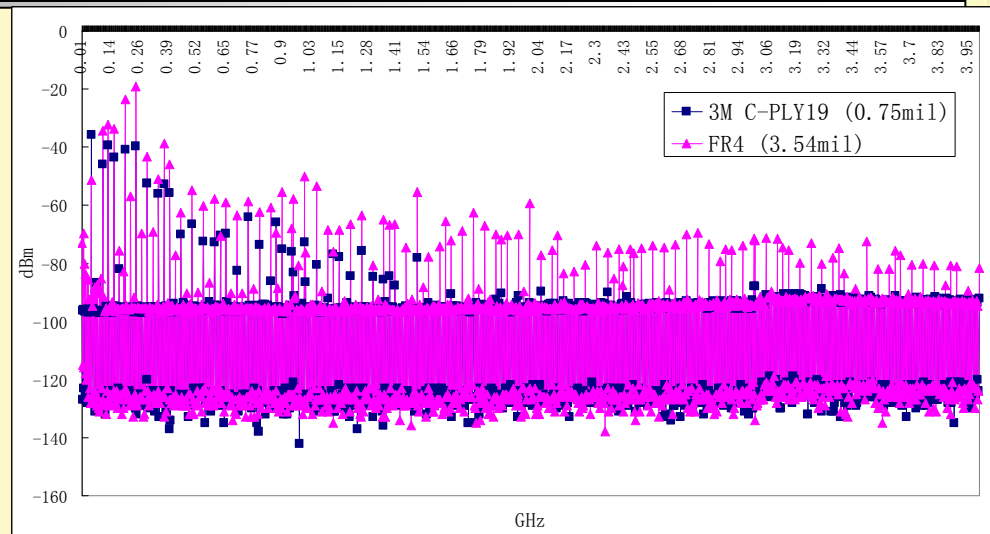
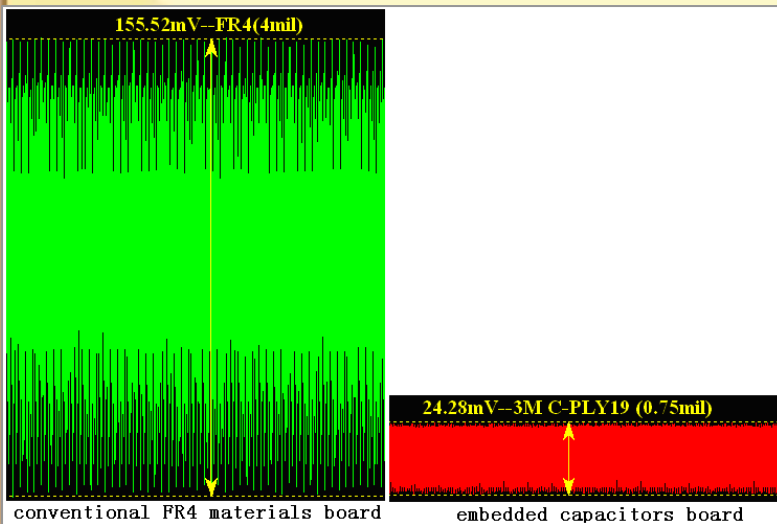
3M C-PLY19 PCB



Impedance Comparison  
Blue for ECM  
Red for thin core FR-4 plate capacitor



# Comparison of the power noise measurement



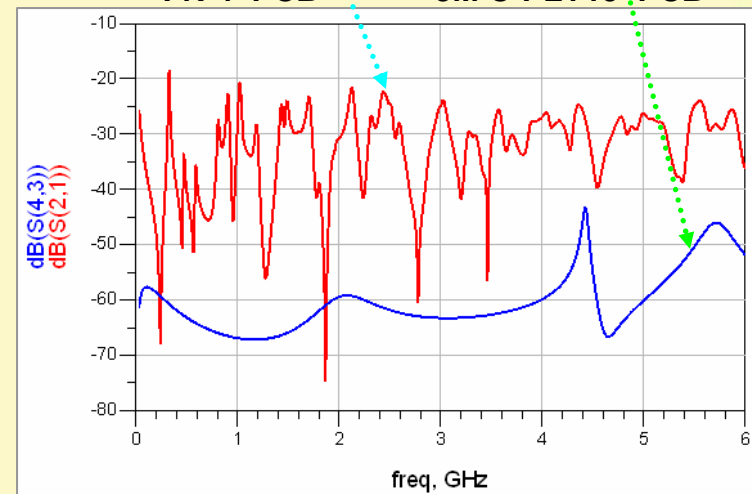
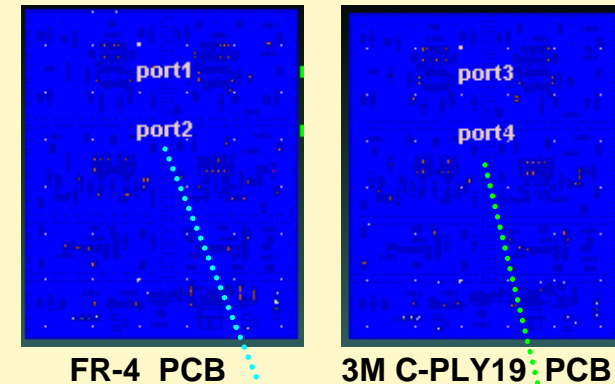
**Power ripple noise comparison in time domain**

**Power noise frequency spectrum comparison**

- Power noise ripple of FR4 board is much higher than that of ECM board.
- ECM board shows superiority over FR4 on noise reduction in entire bandwidth 10MHz-4GHz.
- ECM board noise close to white noise of Spectrum Analyzer in higher frequency over 1.5GHz.
- Very promising for ECM to improve power supply quality, digital /analog interference in board & board level EMI.

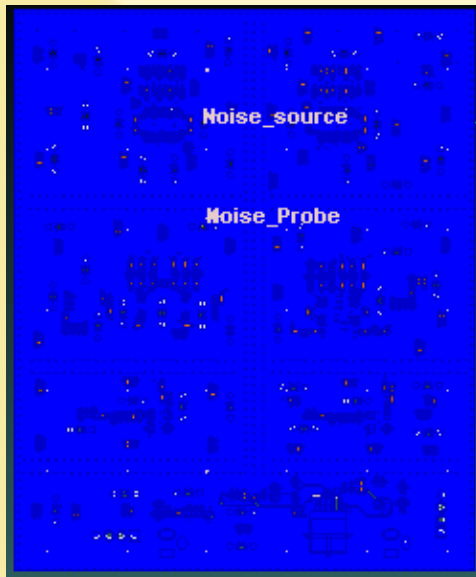
## In Board Interference Analysis for ECM and FR4 Board

- Port set on same connectors position on FR4 / ECM board
- Transmission coefficient between same ports of ECM board is much lower than that of FR4 board
- ECM board minimized risk for interference from shared power distribution system within board

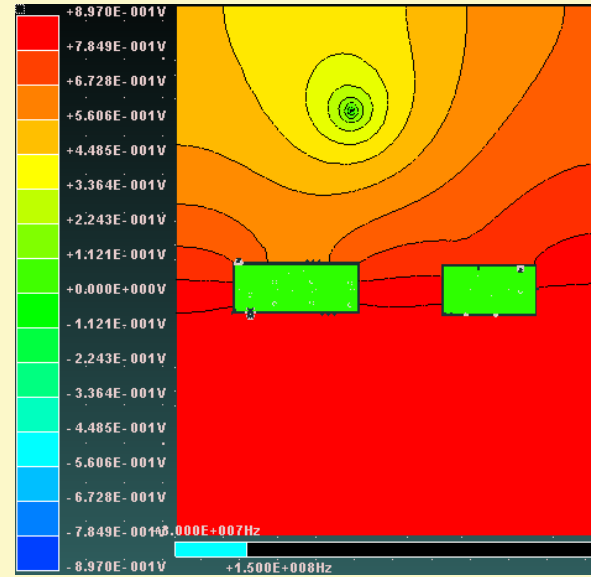


Transmission coefficient comparison  
Red for FR4, Port1,2 ,Blue for ECM, Port3,4

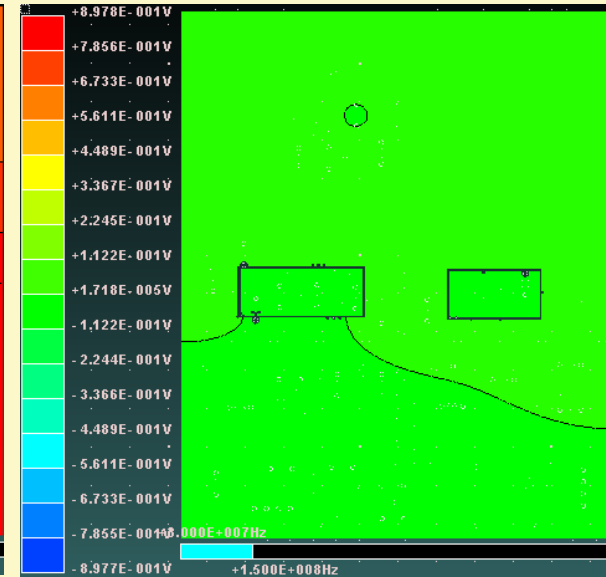
## In Board Interference Analysis for ECM and FR4 Board



Simulation setup



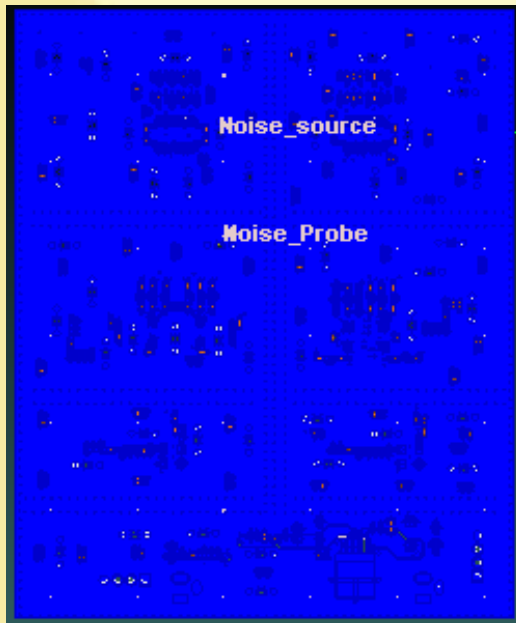
power noise distribution on FR-4 board



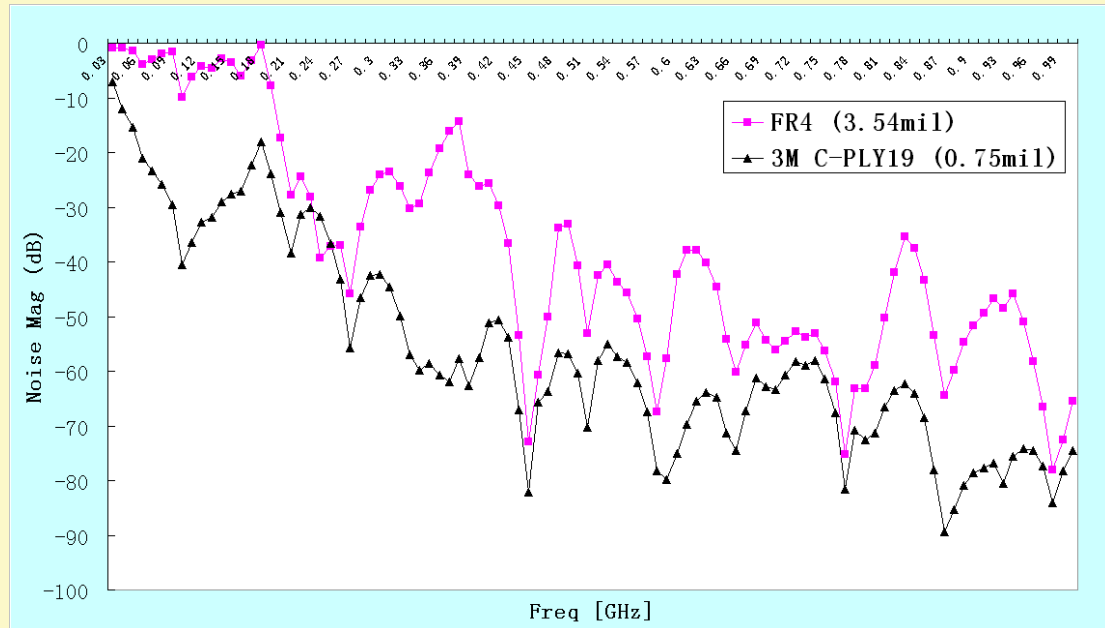
power noise distribution on ECM board

- Set noise source and noise probe on same position of FR4 / ECM board
- Same noise source input
- smaller noise distribution area and lower noise amplitude on power plane for ECM board

# In Board Interference Analysis for ECM and FR4 Board



Simulation setup



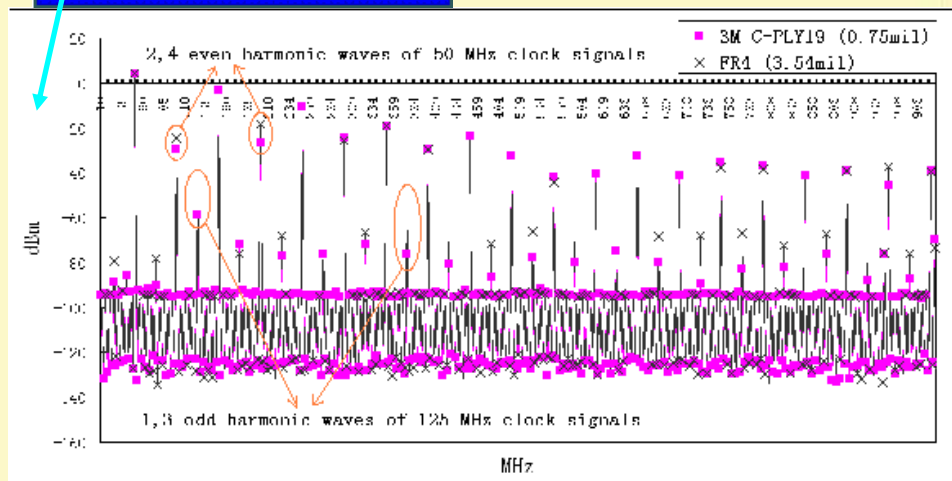
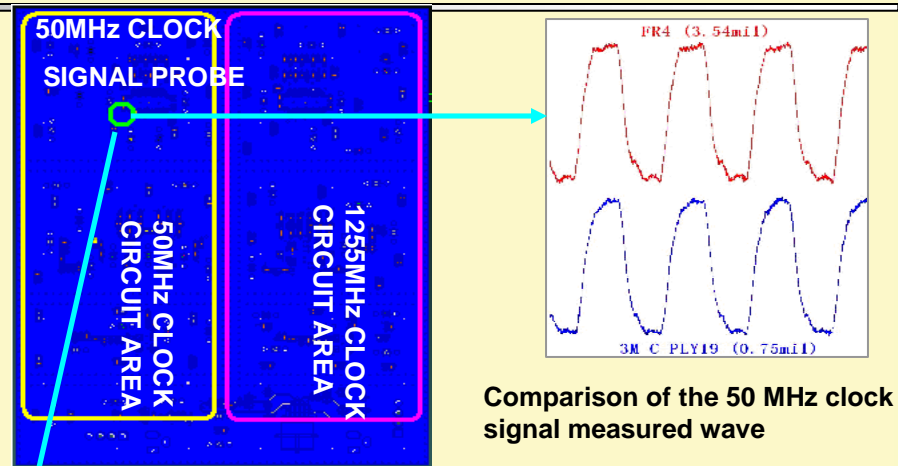
Noise spectrum comparison on same probe position

- Same noise source and probe setup
- Superior noise spectrum of ECM board in all frequency range



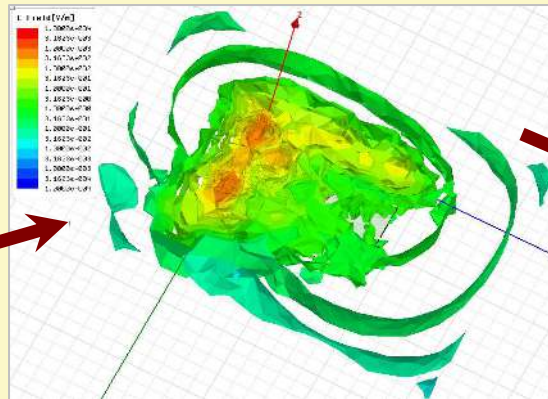
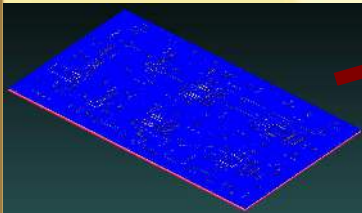
# ECM Impact to Signal Integrity

- Same functional circuit on the board for FR4 and ECM board
- 50MHz & 125MHz clock on different zone but with same power
- 125M Clock as aggressor
- 50M clock as victim to see its signal wave and spectrum received
- 50M clock on ECM board less influenced by 125M clock with better jitter and duty cycle

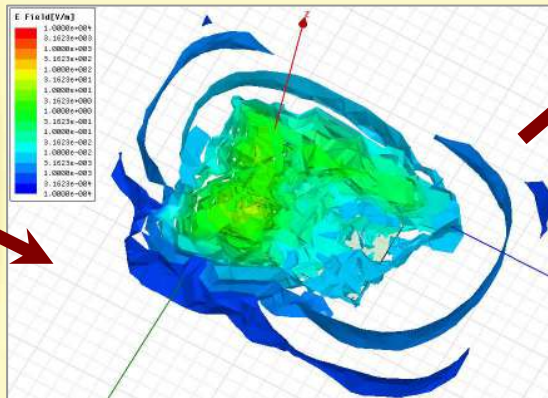
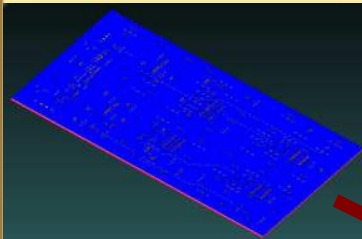


# Board Level EMC Performance Comparison -- Simulation

PCB FR4(3.54mil)

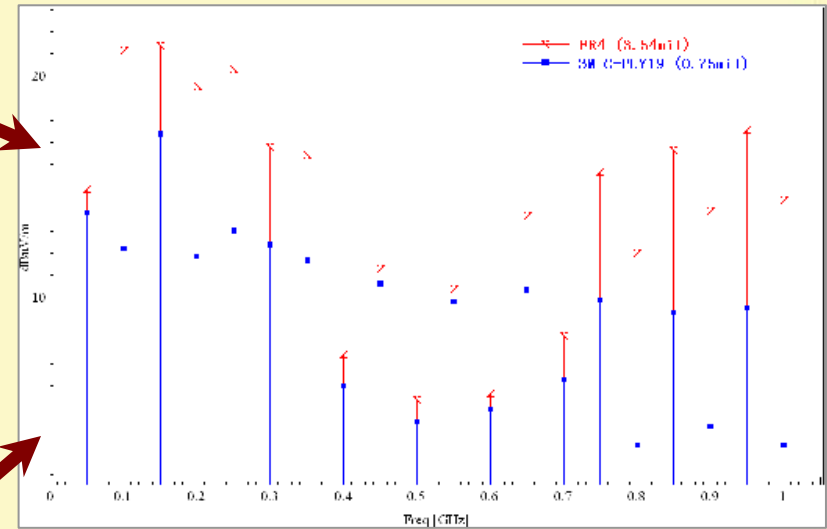


PCB 3M C-PLY19  
(0.75mil)



Free space field distribution

EMI simulation result (3 Meter field)



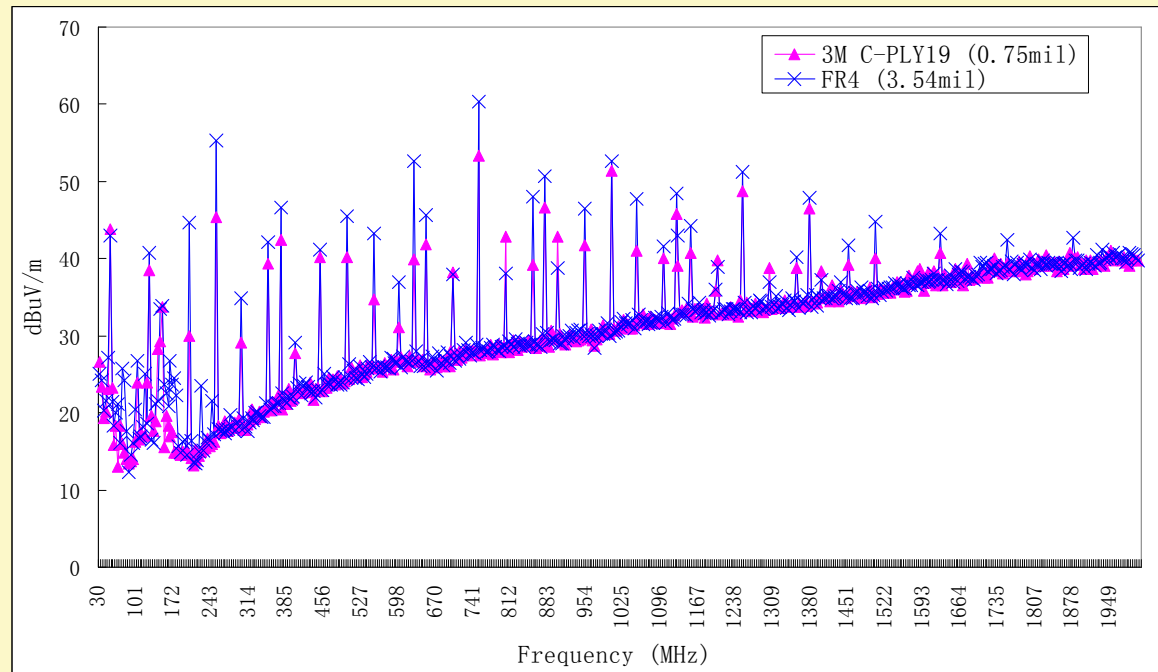
- With same noise source excitation , free space field and 3 Meter field result of ECM board is lower than that of FR4 in all bandwidth simulated



# Board Level EMC Performance Comparison – Test Result



Full Wave Darkroom



Radiated Emission Test Result (30MHz - 2GHz)

- Radiated Emission Test in standard full wave darkwave for FR4/ECM board.
- Obvious better performance of ECM board from 30M to 2G ( only tested up to 2G)



## *The Application Prospect of the Embedded Capacitance Materials*

---

Due to excellent performance of Embedded Capacitance Material in SI , PI , EMC, it will be well suitable for application in:

- 1. Digital/analog Interference Design with Digital/analog Mixed Board*
- 2. EMC Design of the Non-shielding Box-type Products with Plastics shell*
- 3. Power Integrity and Signal Integrity Design of the High Speed and High Density Board*



emc 2010

# Questions

