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08. Feb. 2012

Measurement and Development of Low AC power loss multi layer inductor ~Today and Future~

Applied Power Electronics Conference and Exposition 2012

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FDK corporation

Development of Multi Layer Power Inductor

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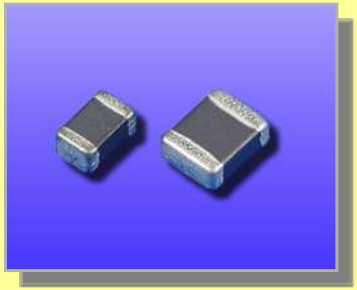
Market requirement of power inductor for mobile device

- High converting efficiency on Power supply
- Small
- Low Leak Noise

Solution

Combining FDK unique technology

- Ferrite technology
- Fine printing technology
- CAE technology



We are optimizing multi layer inductor for DC DC converter and introducing it quickly to the market.

Classification of General Power Inductor

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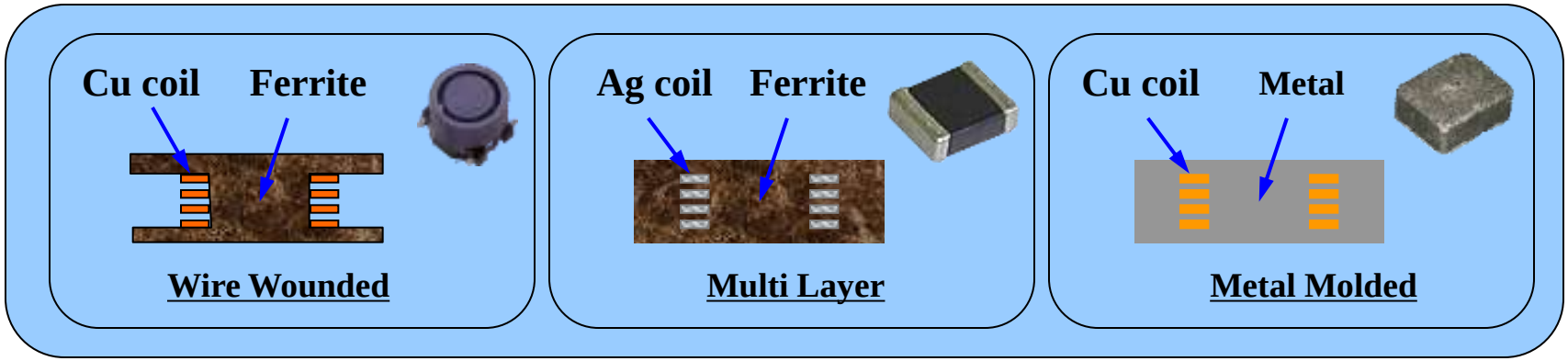
Structure (cross section schematic draw)



Comparison of the characteristic

Score: Bad=1~Best=4

	Magnetic Material	Leak Noise	miniaturize	Frequency properties	Efficiency		DC Bias Characteristic
					Low DC	High DC	
Wire Wounded	Ferrite	1	2	3	2	3	3
Multi -Layer		4	4	4	4	3	2
Metal Molded	Metal	4	1	2	2	3	4

Feature of Multi Layer Power Inductor(1)

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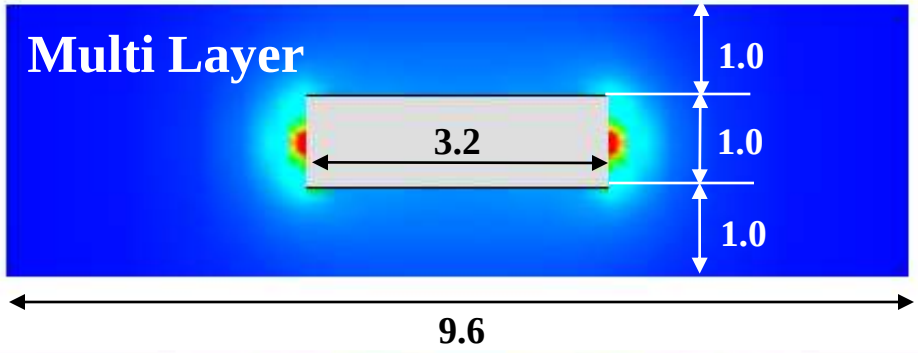
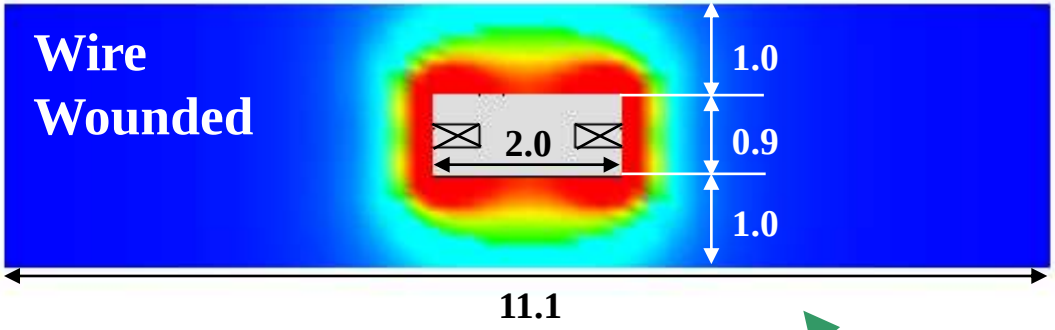
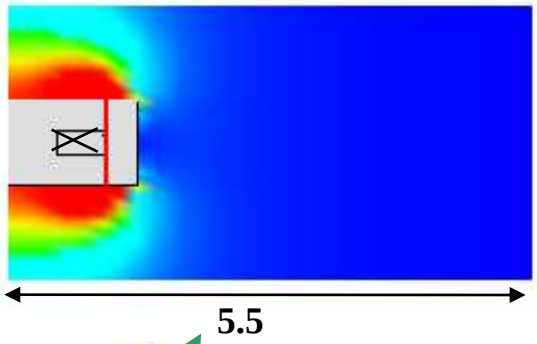
Low Leakage Flux(Simulation Result)

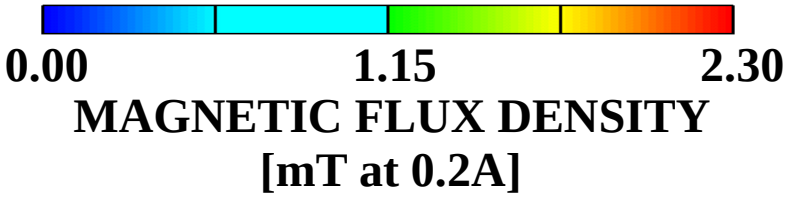


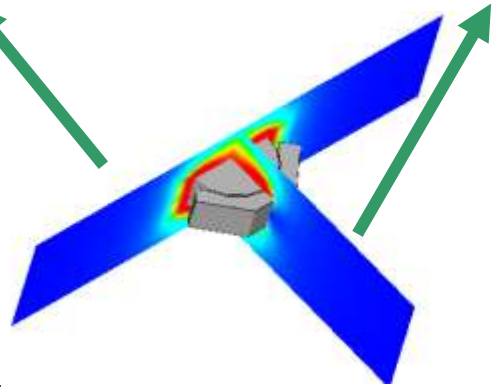
Multi Layer:3.2 * 2.6 * 1.0mm , 10uH

Winding:2.8 * 2.6 * 1.0mm , 10uH









Feature of Multi Layer Power Inductor(2)

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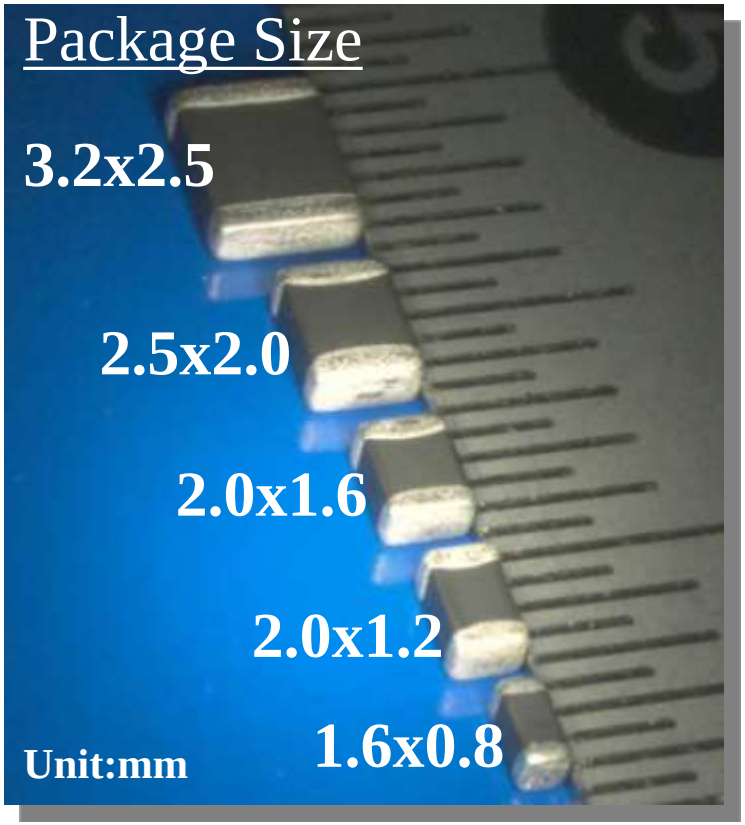
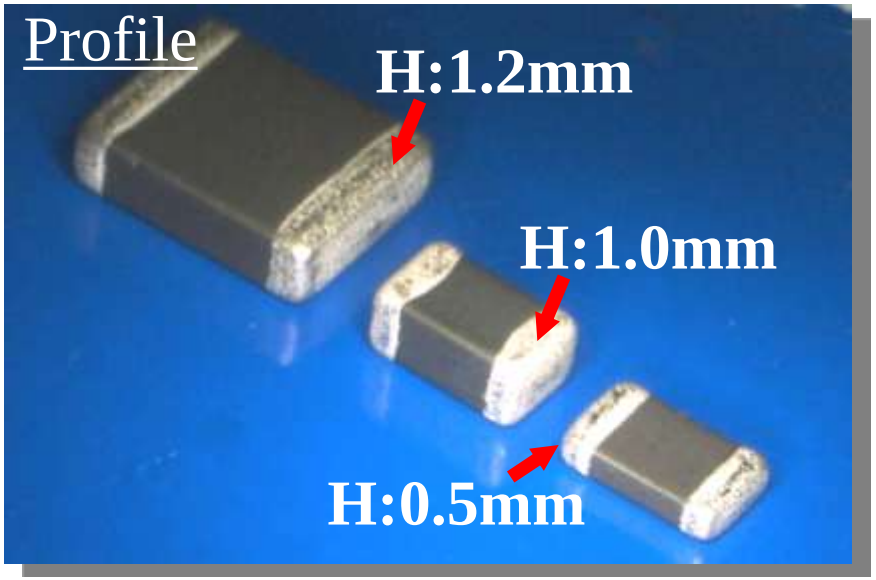
Miniaturize(including thickness)





- **Smallest package size: 1.6x0.8mm**
- **Lowest profile : 0.5mm**

Feature of Multi Layer Power Inductor(3)

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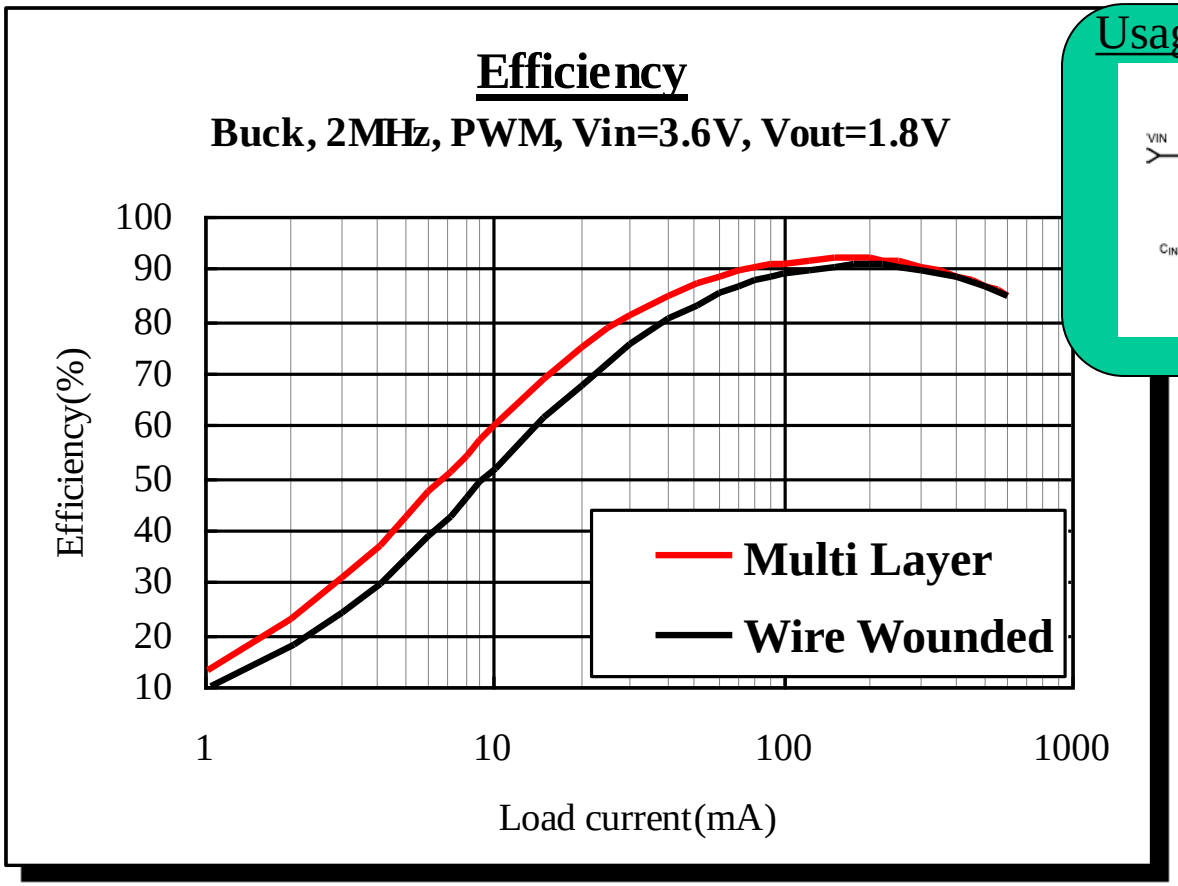
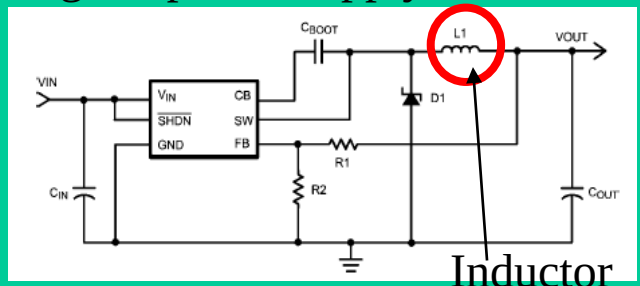
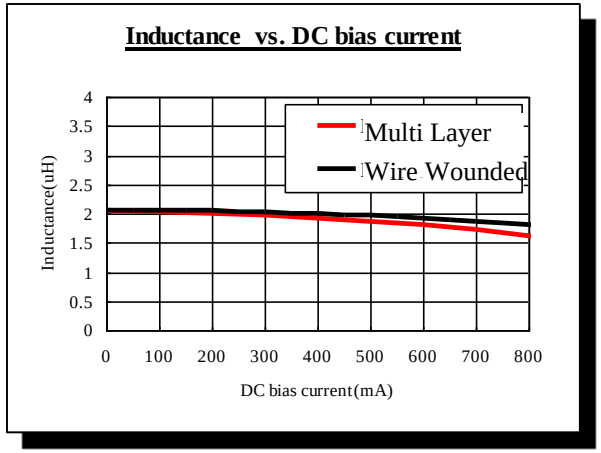
High converting efficiency



Usage in power supply





RDC of Multi layer and wire wounded is same as 0.11Ohm.

Efficiency & Inductor Characteristic

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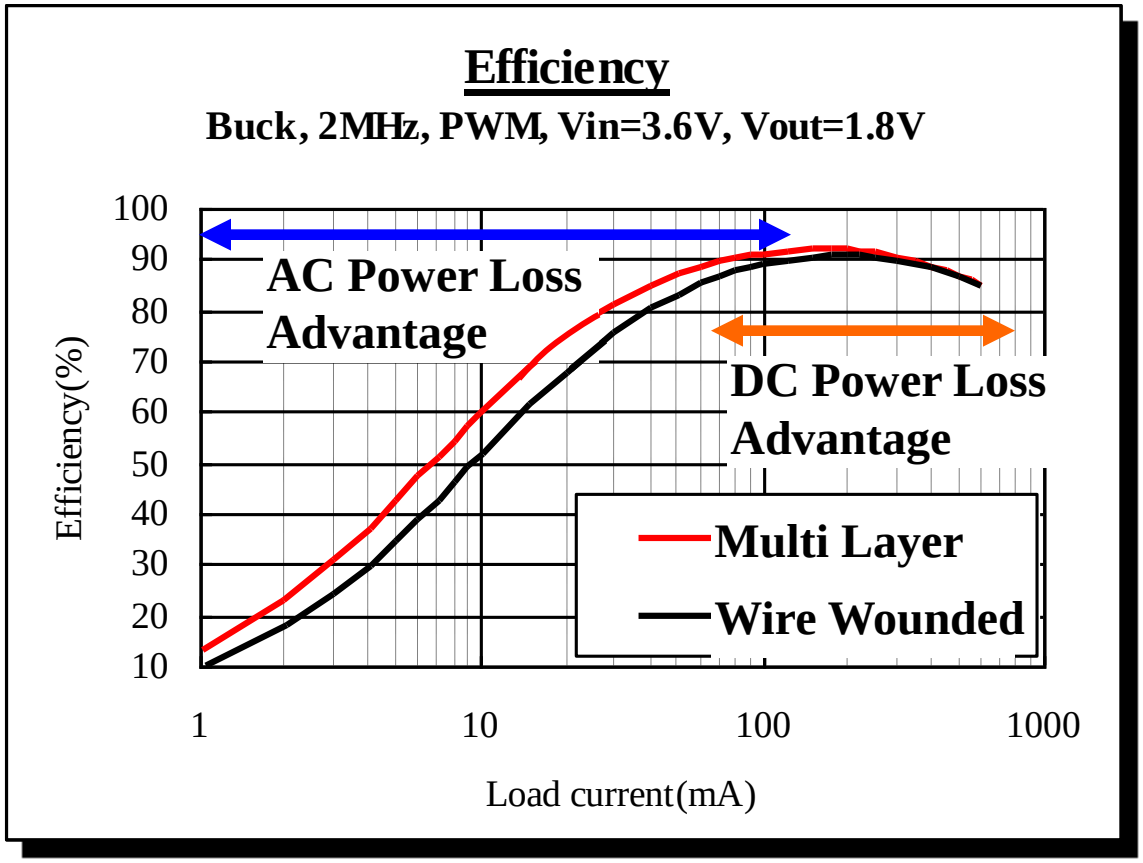

Efficiency(%) = 100 - (Switching Loss(%) + Inductor Loss(%))

Inductor Loss = AC Power Loss + DC Power Loss
(AC Resistance) (DC Resistance)

Method of reducing AC power loss

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Magnetic Material

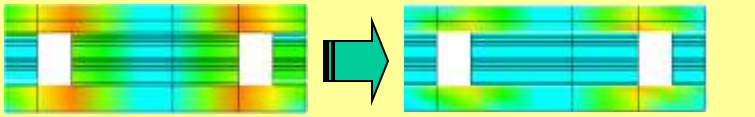
Optimizing
- Material composition
- Sintering condition
- And more

Low AC Power Loss Material

Inner Structure of inductor

About inner structure

Optimizing the shape of coil pattern, coil thickness, other dimension by CAE technology.



Previous　　Optimizing inner structure

Magnetic flux at same DC bias

Reducing AC power loss

Reduction of AC power loss(Material)

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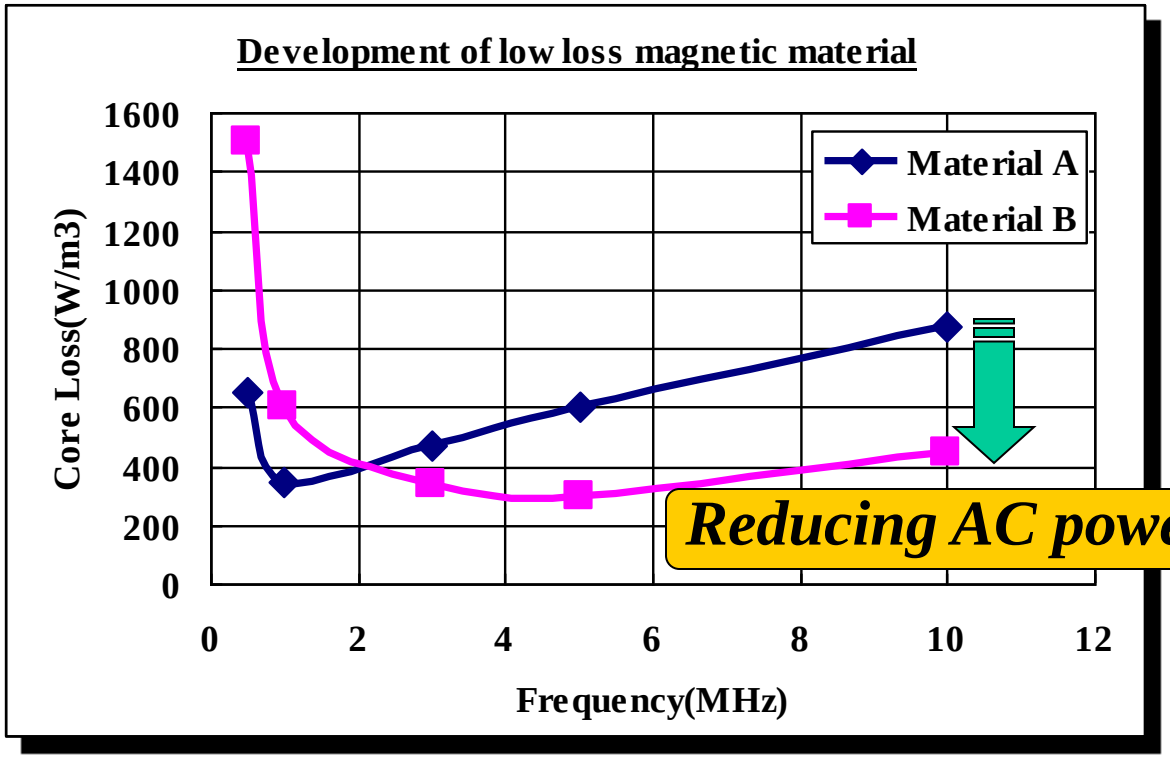
Material A: Original magnetic material
Material B: New material for higher frequency



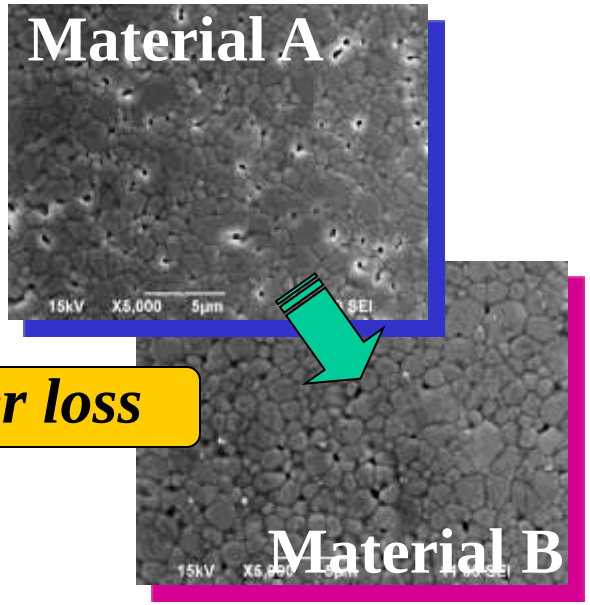


Fig. SEM image of ferrite material

Reduction of AC power loss(Structure)

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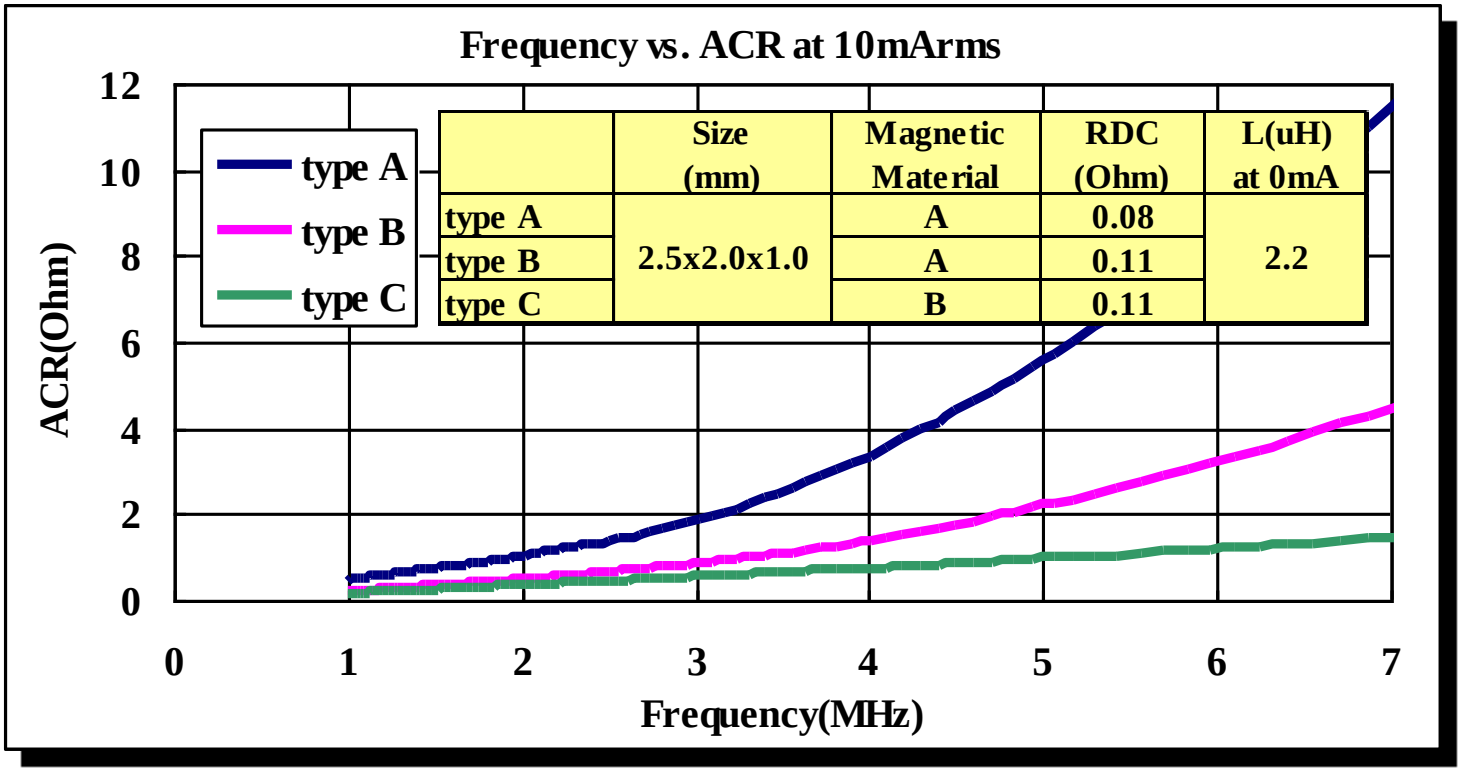

	Size (mm)	Magnetic Material	RDC (Ohm)	L(uH) at 0mA
type A	2.5x2.0x1.0	A	0.08	2.2
type B		A	0.11	
type C		B	0.11	

Type A: Before optimizing inner structure, applied magnetic material A

Type B: Optimizing inner structure, applied magnetic material A

Type C: Same structure as type B, applied magnetic **material B**

ACR

type A > type B > type C

AC power loss measurement based on actual usage

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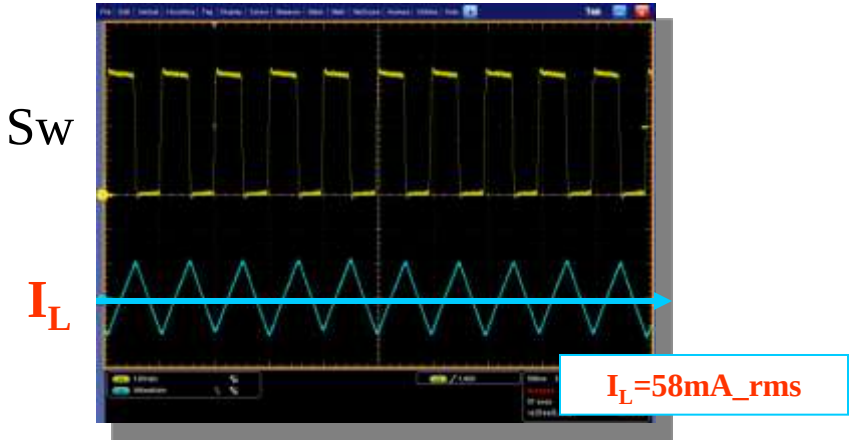
General at Measure <20mA rms

On Actual usage >20mA rms

*Iout=at 200mA

Measurement:
Agilent 4284A(Irm 10mA)



Measurement:
Oscilloscope

How to measure by large amplitude?
How much is AC resistance at power supply working on?

AC power loss measurement by BH Analyzer

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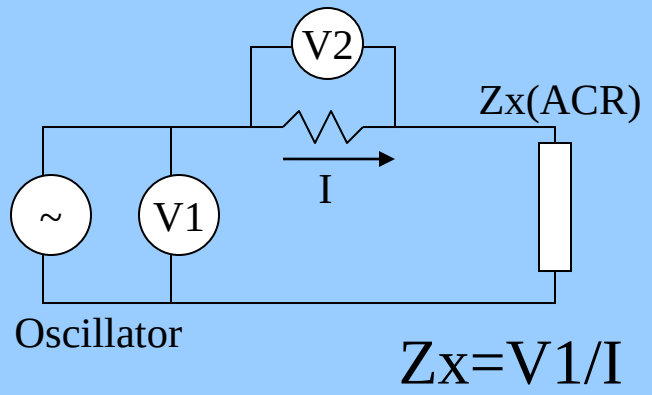
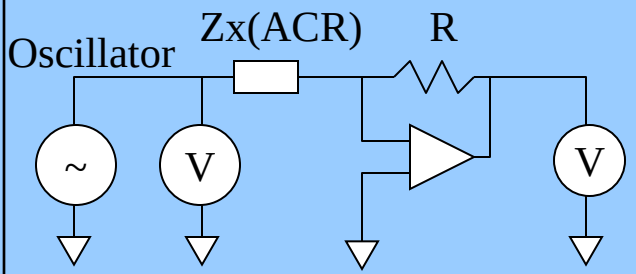
ACR Measurement by BH Analyzer

	Frequency (MHz)	Amplitude	Measurement method
BH analyzer (SY-8232 Iwatsu) 	**<10MHz**	**>1Ap-p**	
Impedance analyzer (4284A Agilent) 	**<110MHz**	**<20mArms**	

Measurement result by BH analyzer

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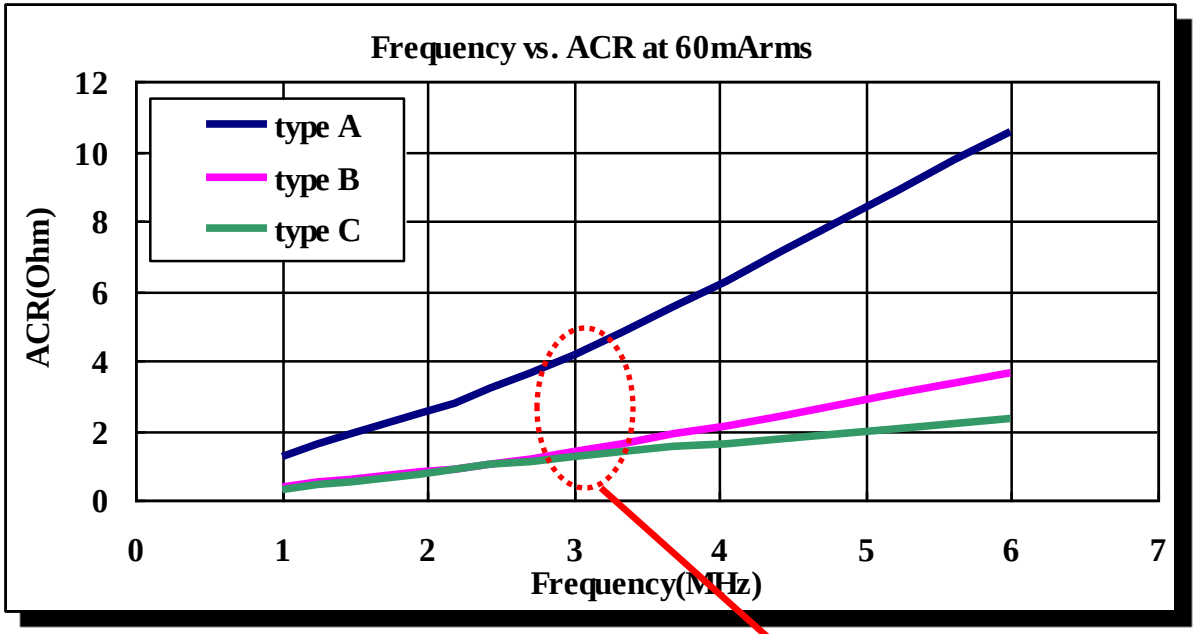
Ex. Measurement Result

System:SY-8232 Iwatsu, IL=60mA rms, Frequency=1~6MHz



	At 3MHz	
	10mA rms	60mA rms
Type A	2.4 ohm	4.1 ohm
Type B	1.3 ohm	1.4 ohm
Type C	0.6 ohm	1.2 ohm

Loss Analysis Appling ACR by BH Analyzer

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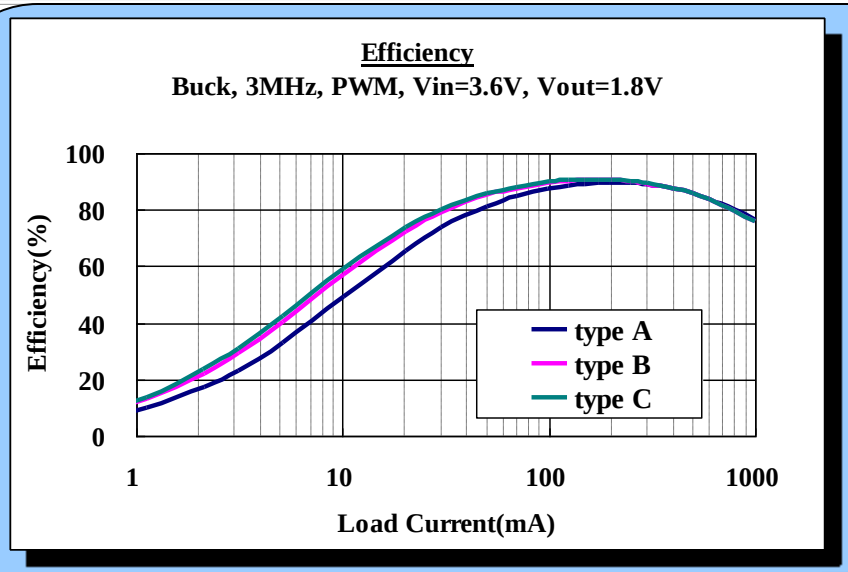

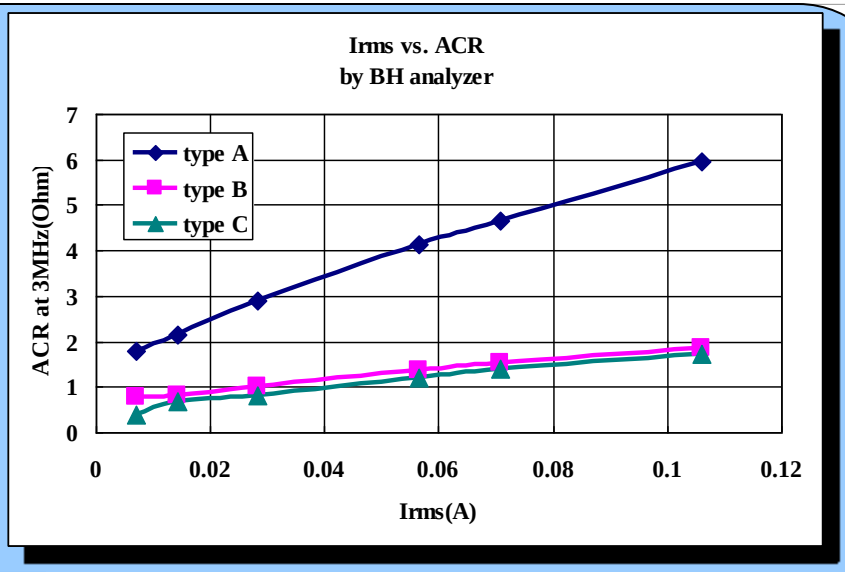

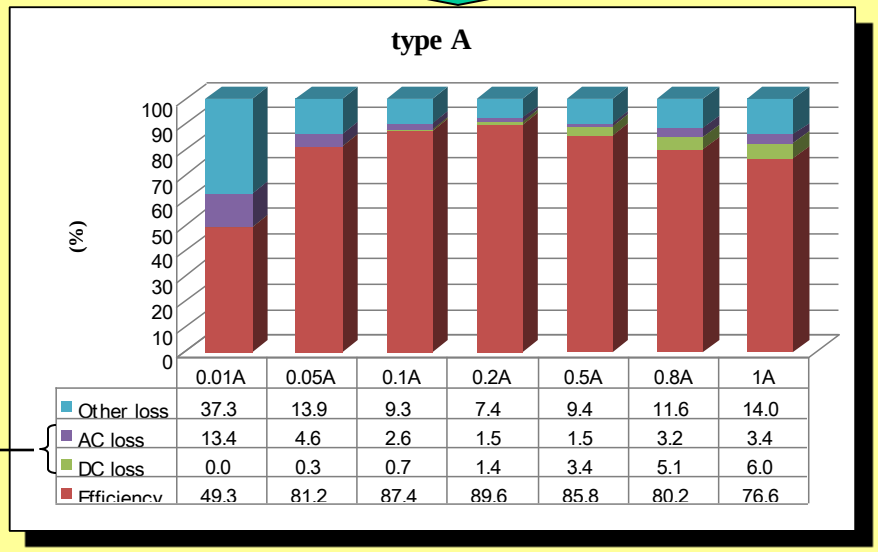

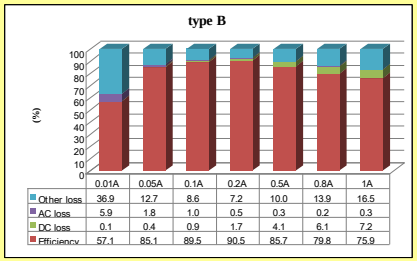

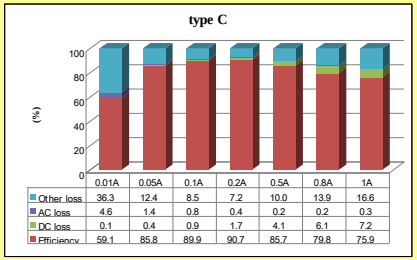

Inductor Loss:
AC loss=ACR x $I(L)^2$
DC loss=DCR x $I(load)^2$

Direction of development to the future

- Corresponding to higher switching frequency(over 6MHz)
  Starting development new magnetic material
- Smaller
  1608 size inductor has been achieved.
  Starting development for 1005.
- Thinner
  0.5mm thickness has been achieved.
  Starting development less than 0.3mm.

Next Multi layer Power inductor(small and efficiency)

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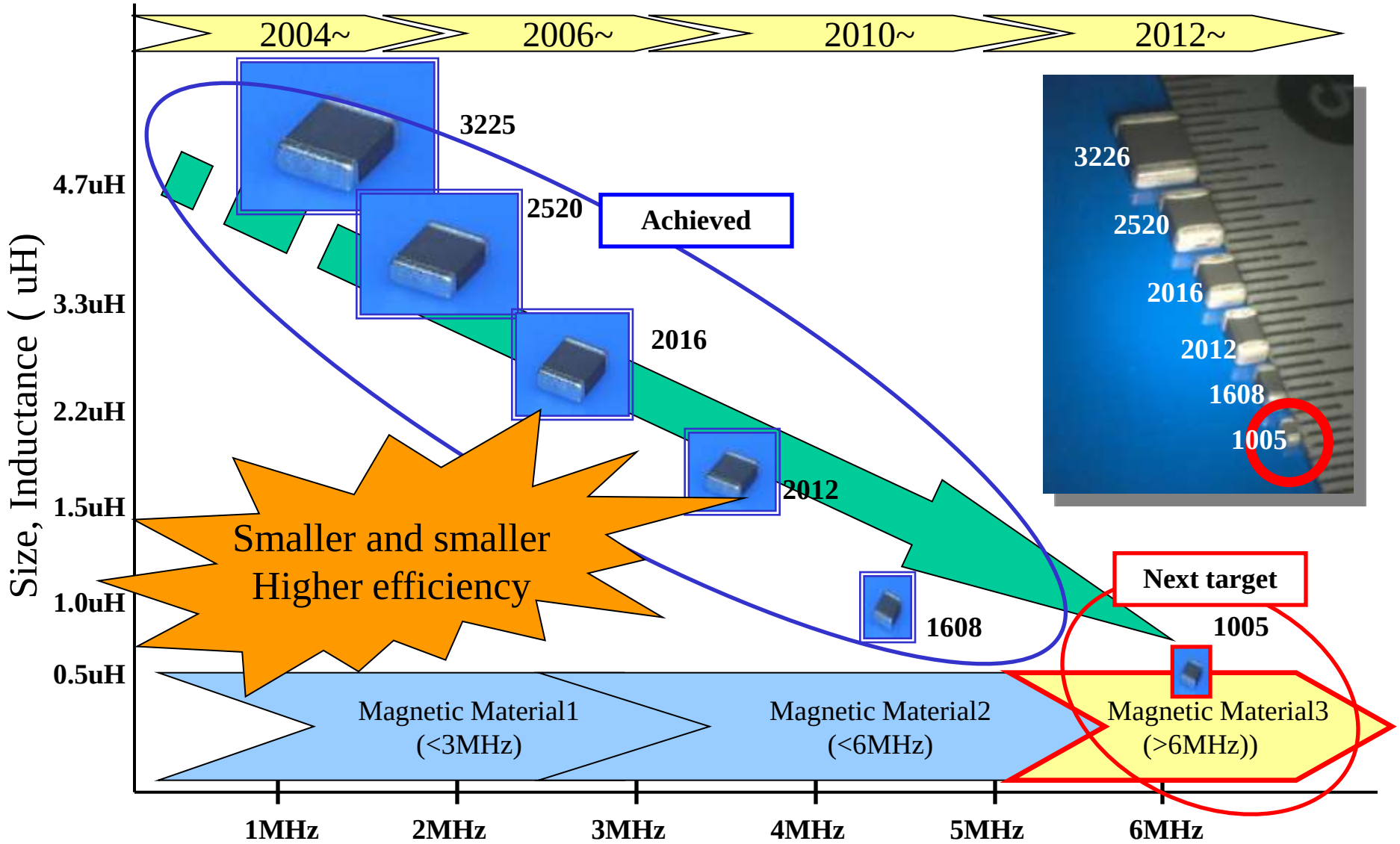

Next Multi layer Power inductor

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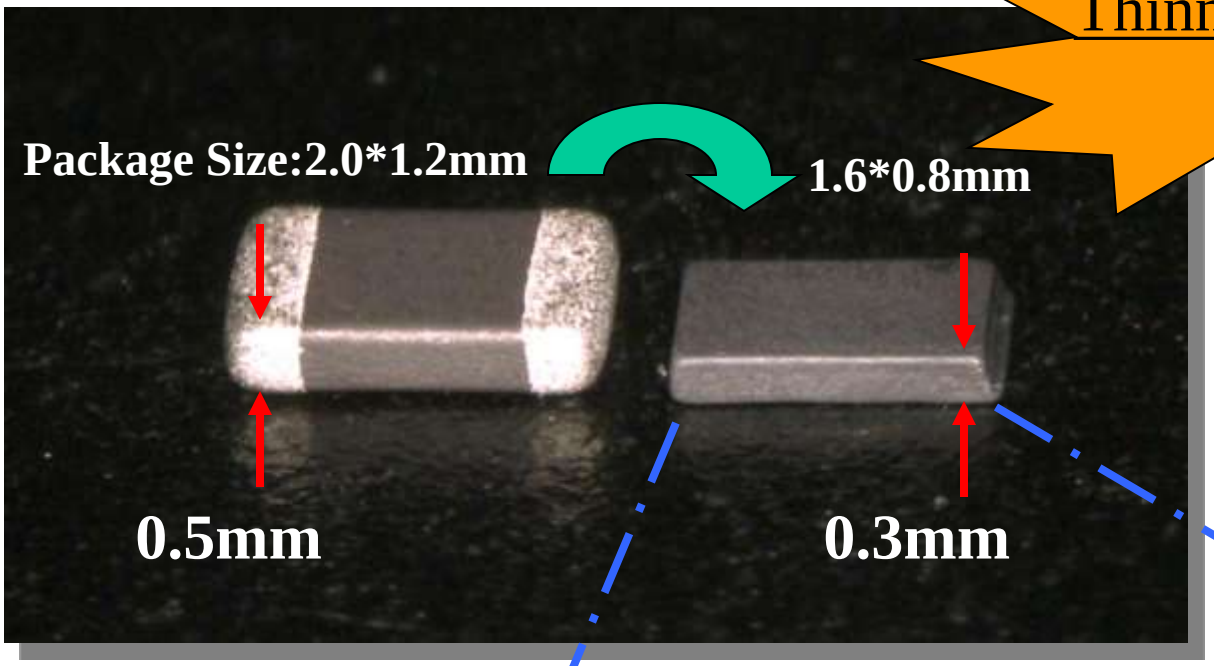
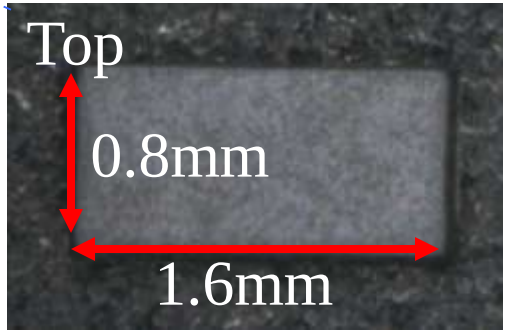
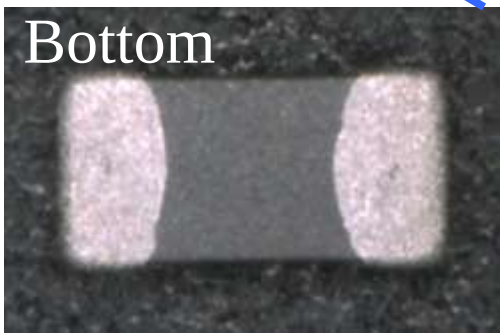
Thinner and Thinner
(0.3mm)







Summary

- Introducing Multi Layer power inductor
- How to improving AC resistance
- AC power loss measurement based on power supply usage
- Next development(smaller, thinner, for higher frequency)

Thank you for listening!

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