

Present status of FINEMET® Pulse Power Core for Accelerator Cavity

Contents

1. FINEMET® products
2. Manufacturing process
3. Example for accelerator application
4. Conclusion

KATSUHIRO OGURA
FINEMET BUSINESS DEVELOPMENT OFFICE
Hitachi Metals,Ltd.

FINEMET® products

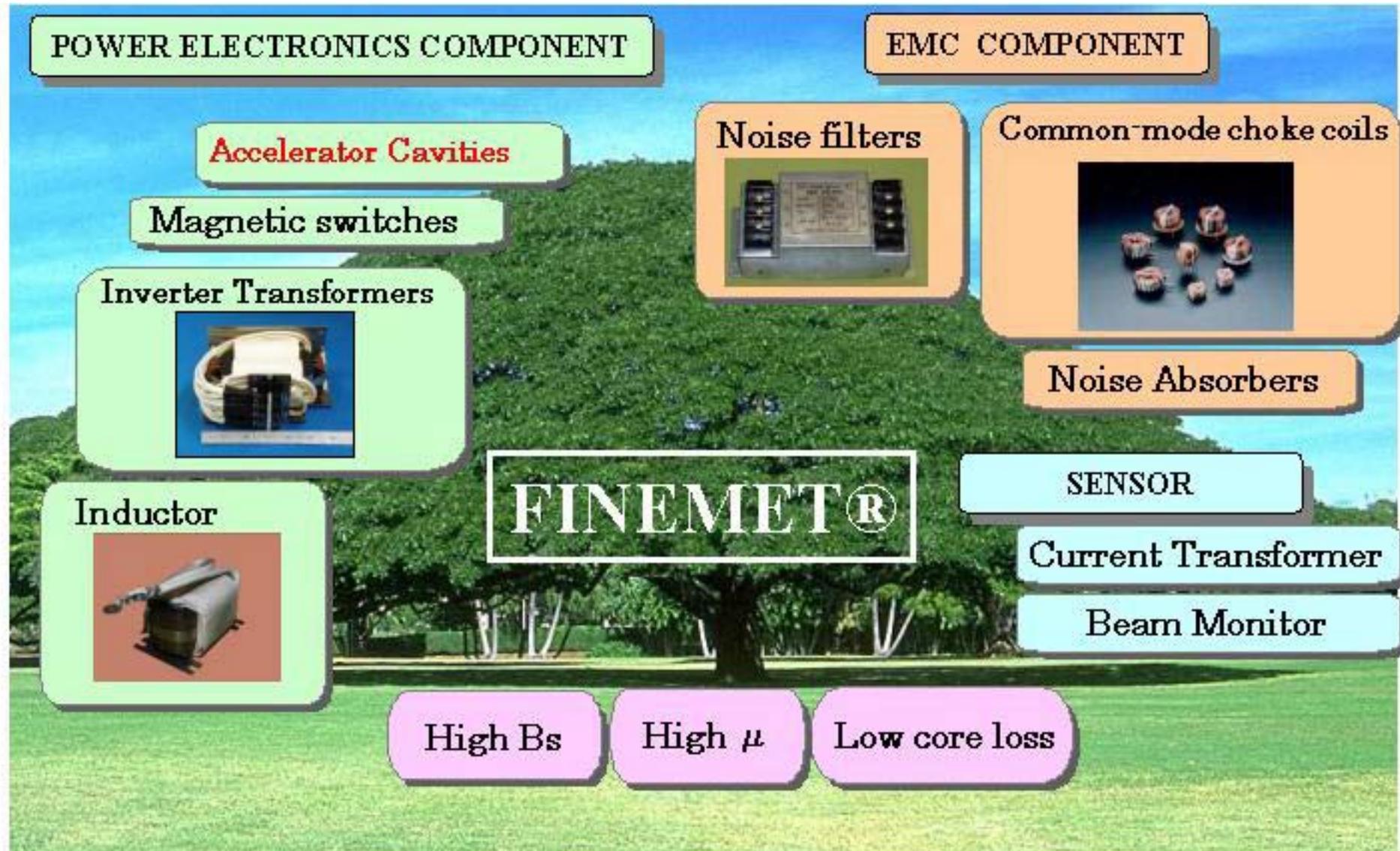


Fig 1. FINEMET® Products

Manufacturing process(Tape)

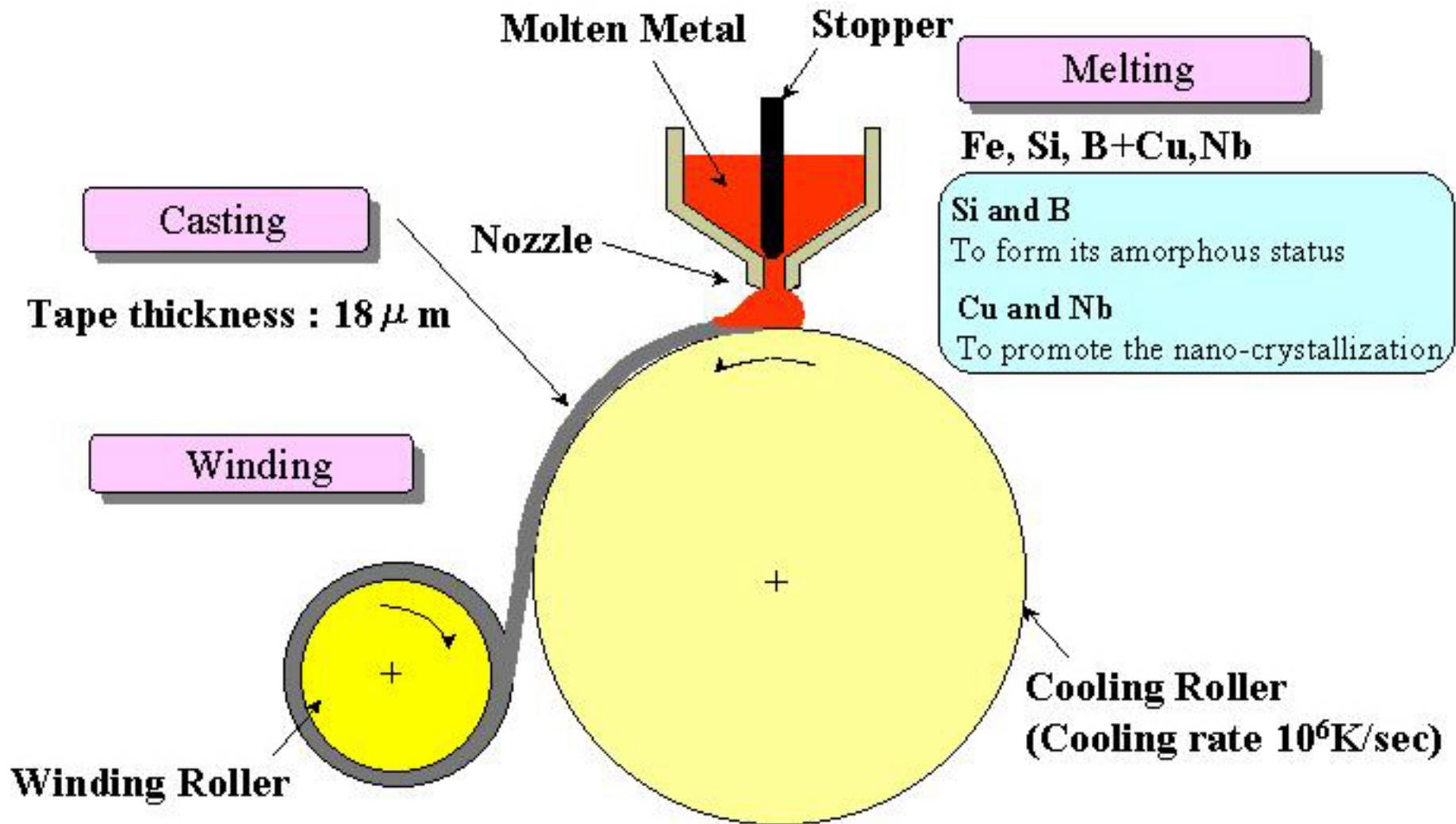


Fig 2. Rapid Quenching Process

Manufacturing process(Core)

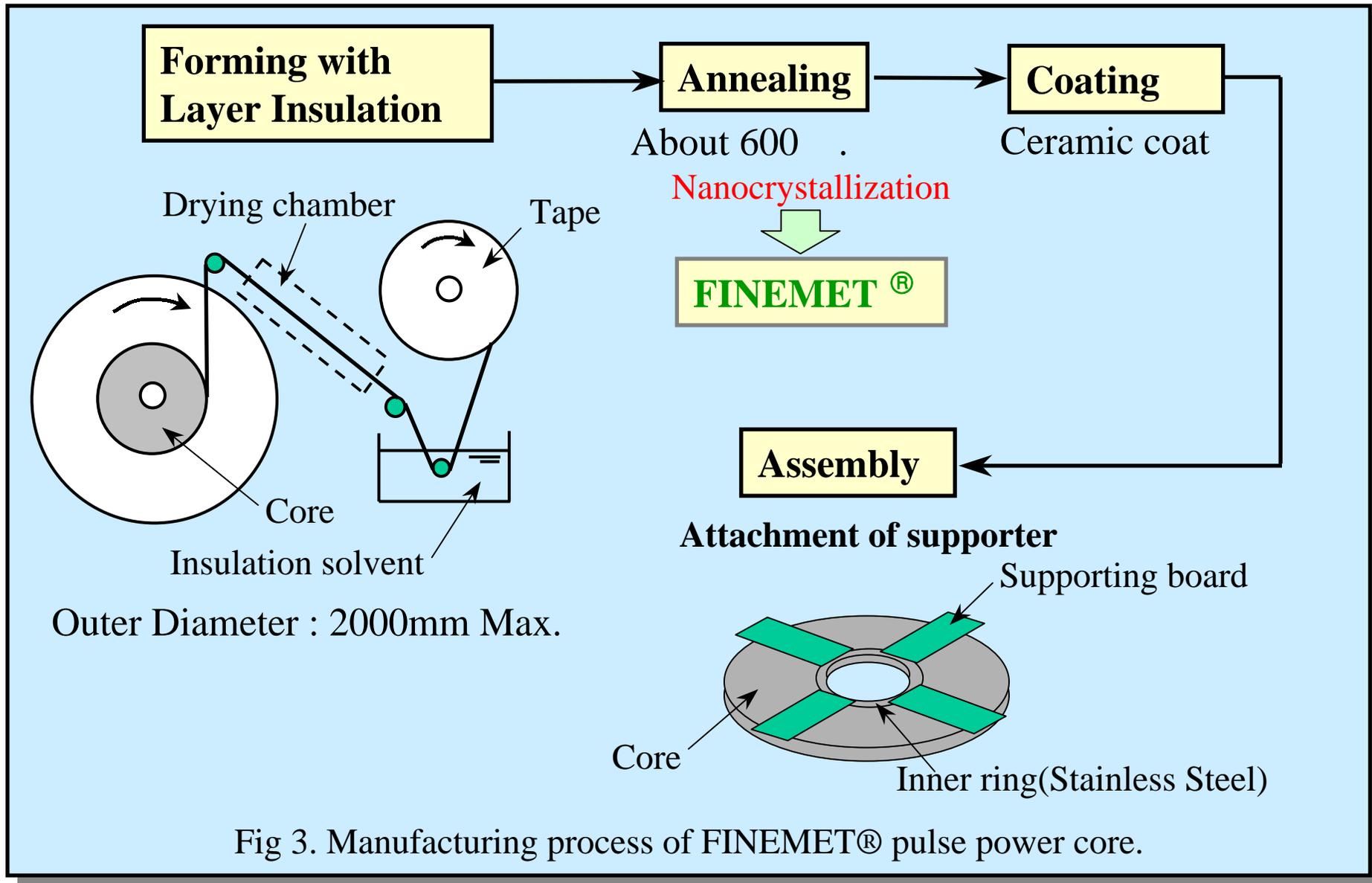


Fig 3. Manufacturing process of FINEMET® pulse power core.

Example of FINEMET® type for Accelerator cavities



Table 1. The example of FINEMET® type for accelerator cavities.

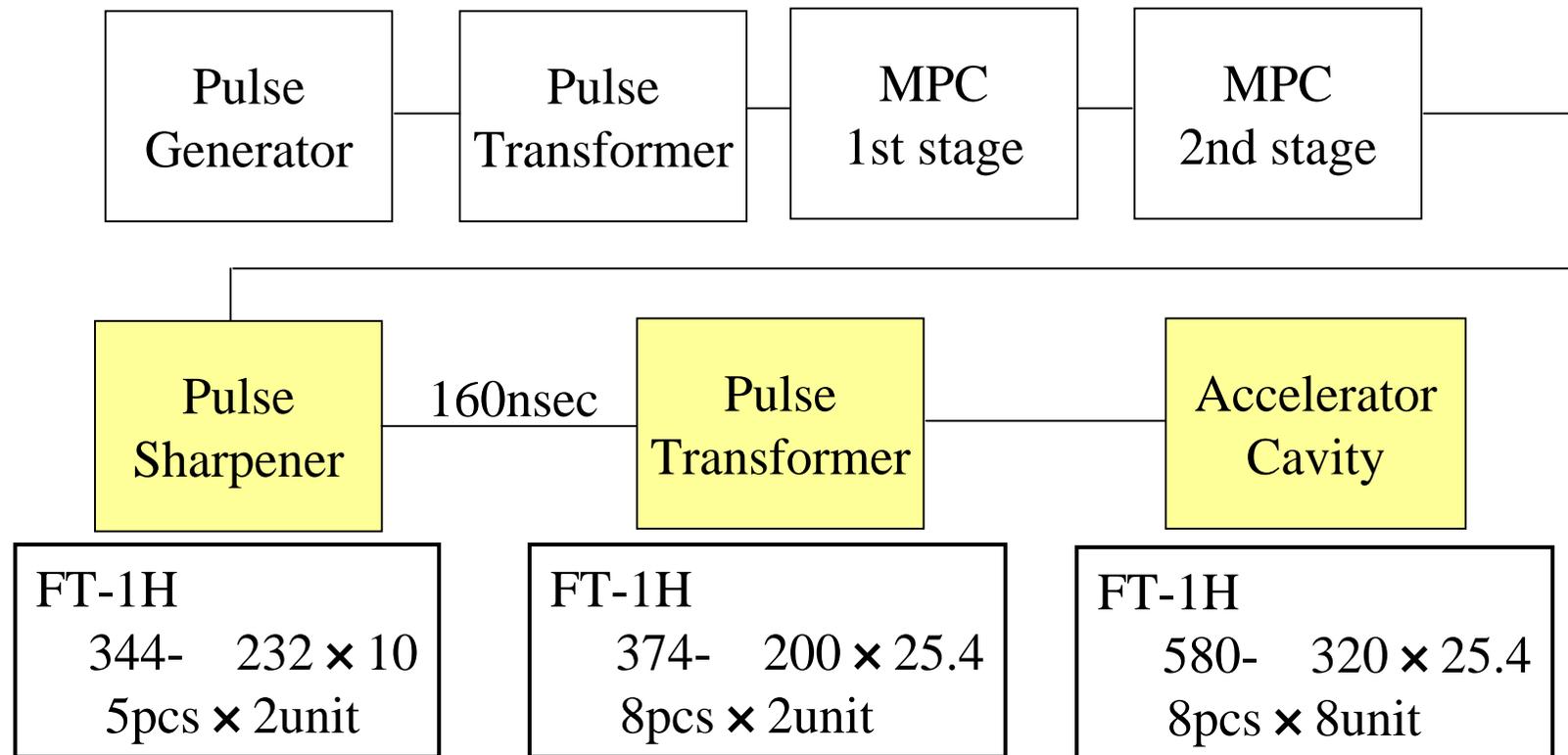
Customer	Accelerator Type	FINEMET® Type	Requirements for Magnetic cores
(JAERI)	Induction Linac	FT-1H(18 μ m)	High B Low core loss
(KEK)	FFAG synchrotron	FT-3M(18 μ m)	High μ Qf High Bs
(KEK)	Induction synchrotrons	FT-3M(15 μ m)	lower core loss

(JAERI) means Japan Atomic Energy Research Institute
(KEK) means High Energy Accelerator Organization

Example of application for accelerator 1

Application : Induction Linac(LAX-)

Customer : (JAERI)



Requirement: **High B , Low core loss, High Curie Temperature.**

Fig 4. Schematic diagram of JAERI's Induction Linac

Electrical characteristics of FINEMET® FT-1H Core.



Table 2. Electrical Characteristics of FINEMET® FT-1H Core

	B (T)	Core loss(J/m ³) *
FINEMET® FT-1H	1.76	1000
Fe-based Amorphous	2.04	1800
Ni-Zn Ferrite	0.65	160

*Pulse width=0.5 μ sec

Bms vs Temperature

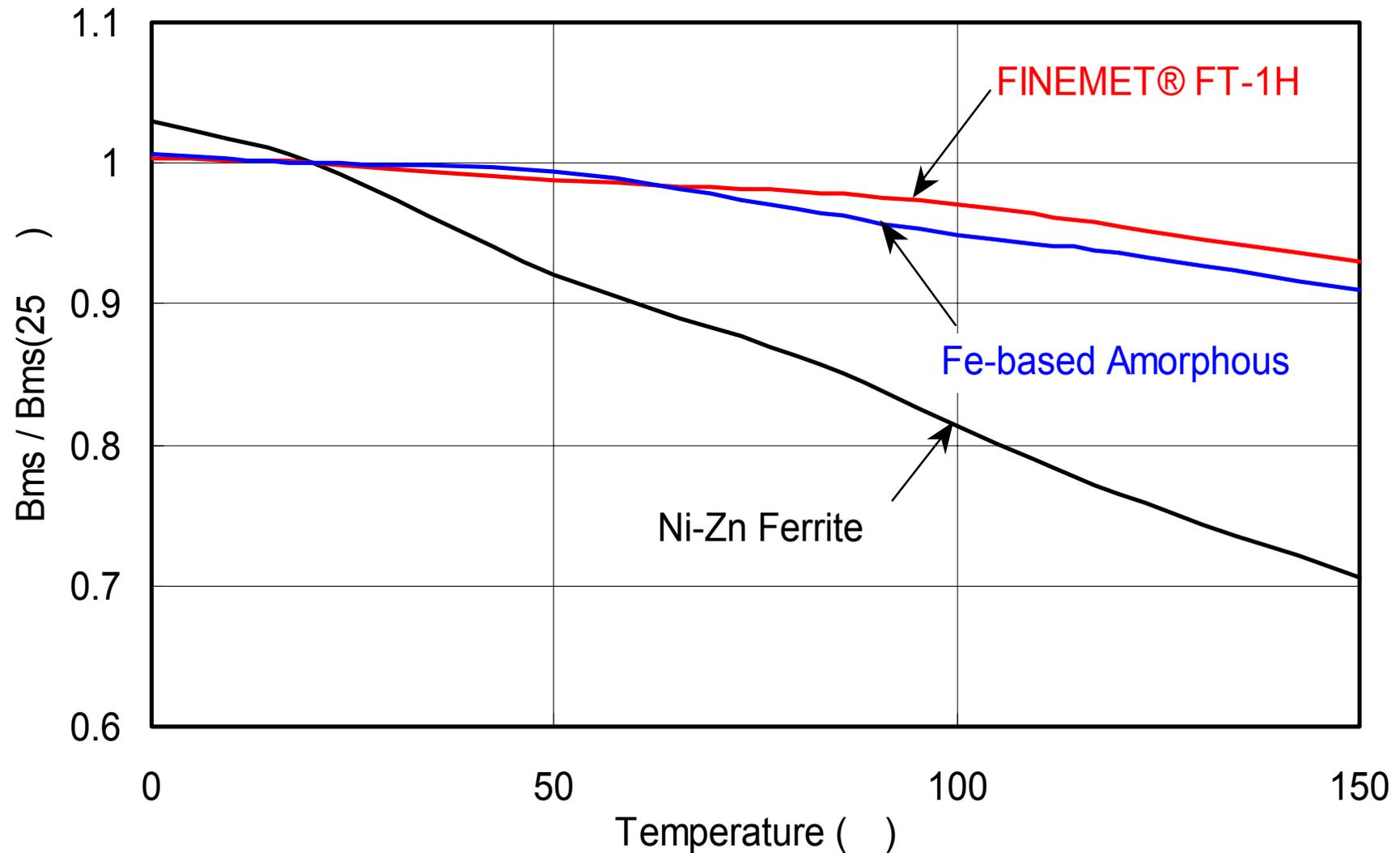


Fig 5. Temperature dependence of saturation flux density

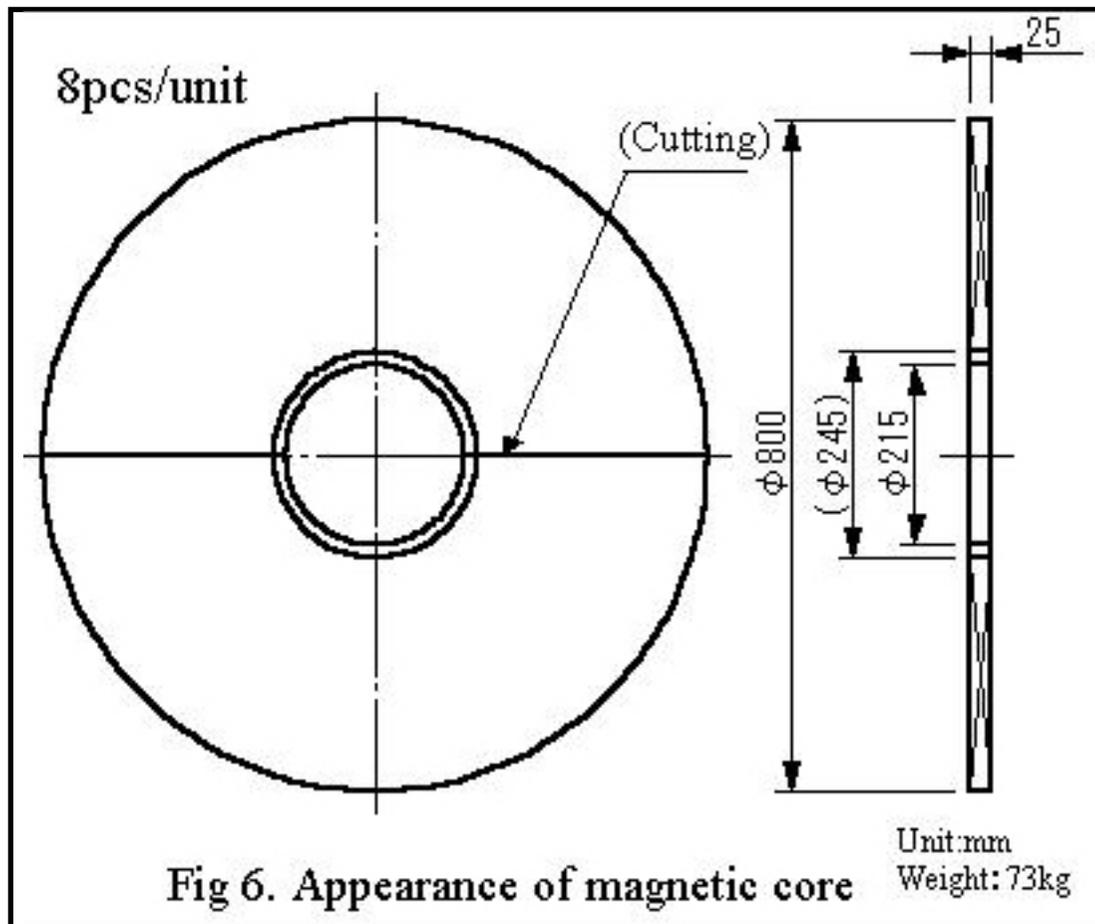
Example of application for accelerator 2



Application : Accelerator Cavity for FFAG synchrotron

Customer : (KEK)

Appearance



Material :

FINEMET® FT-3M

(18 μ m)

Requirement :

High μ Qf

High Bs

Low core loss

Complex permeability vs Frequency

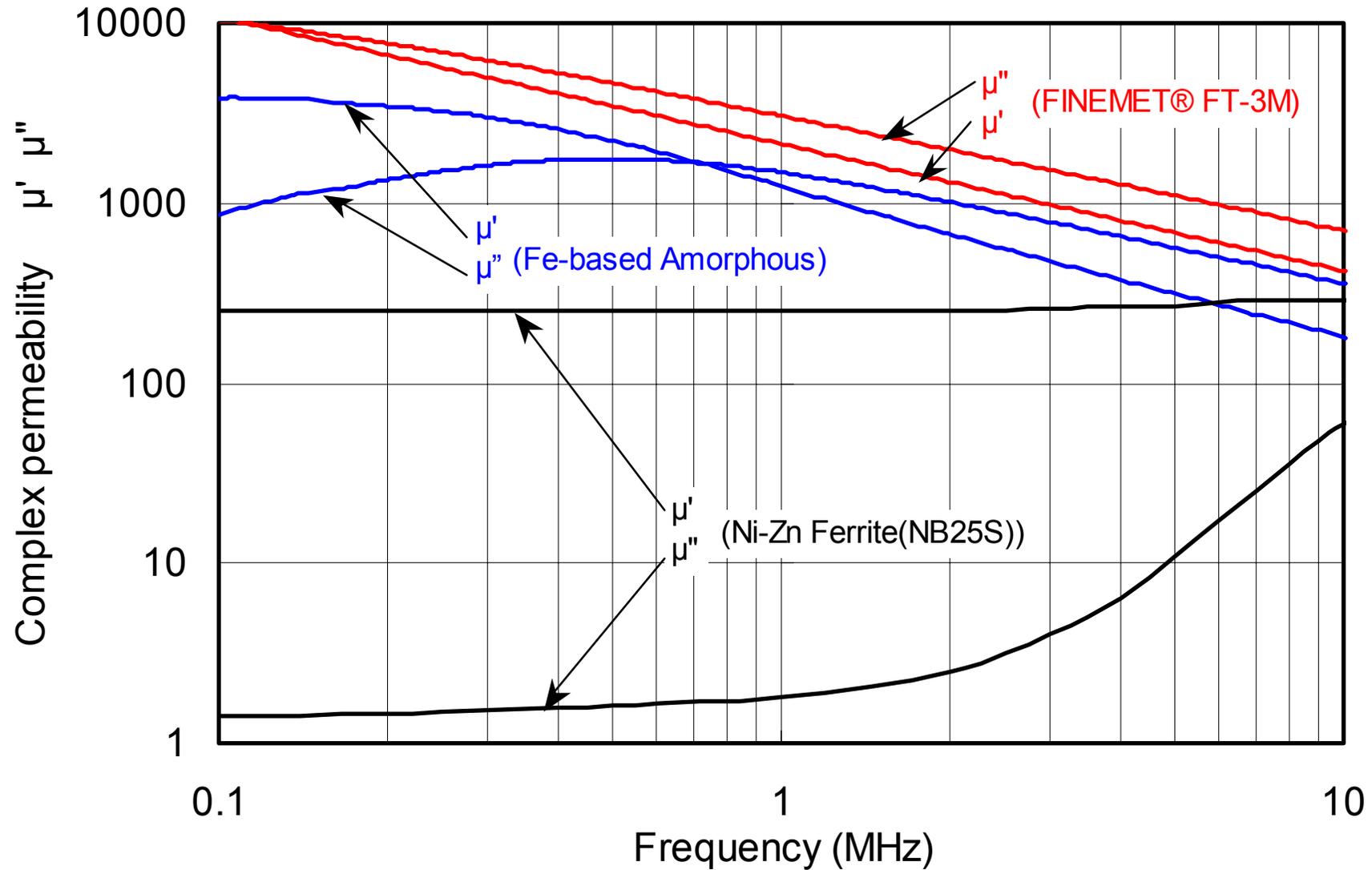


Fig 7. Comparison of Complex permeability.

μQf Value vs Frequency

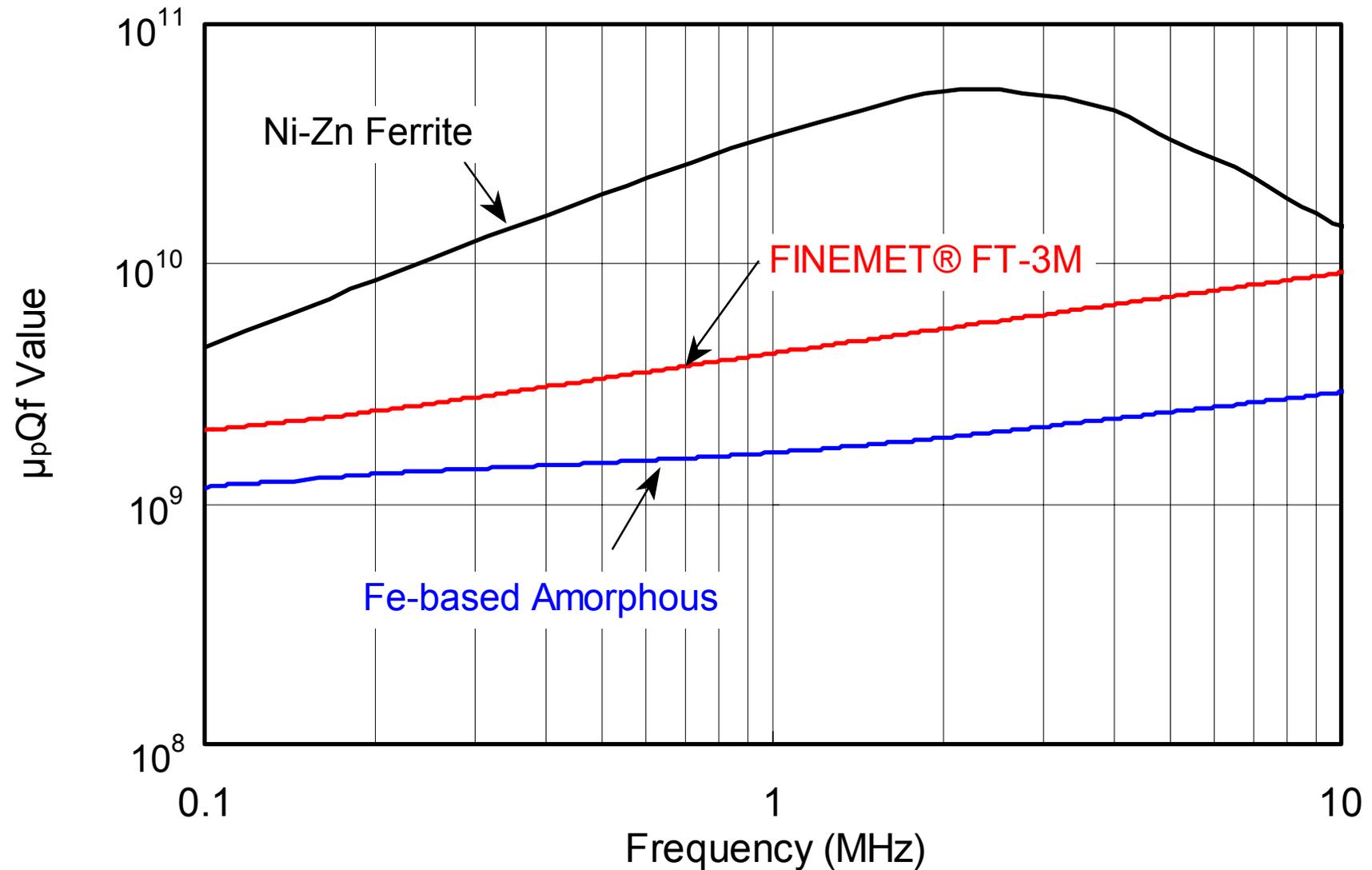


Fig 8. Comparison of μQf value.

Flux density dependence of μQ_f value

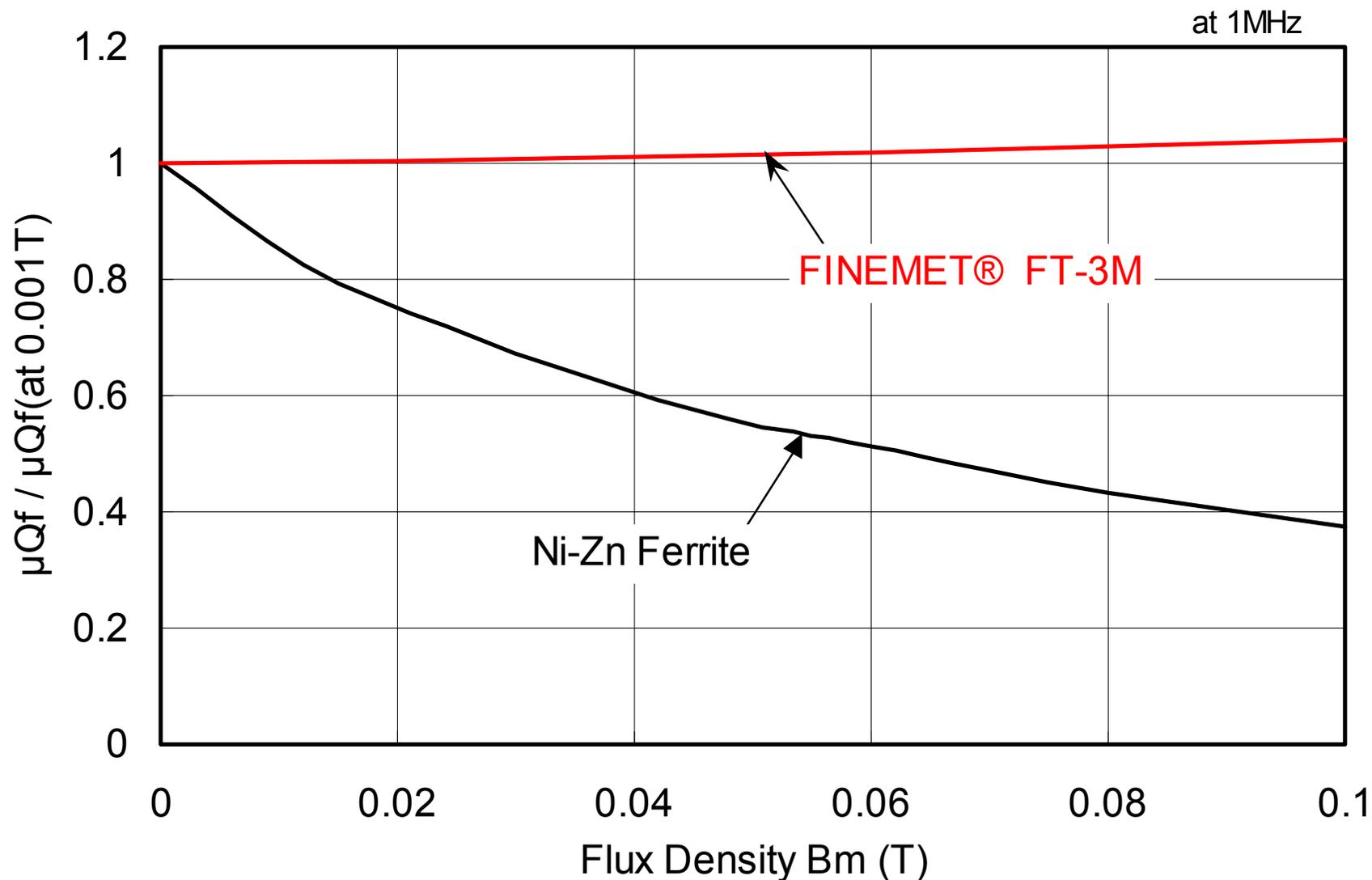


Fig 9. B_m dependence of μQ_f value.

Core loss vs Frequency

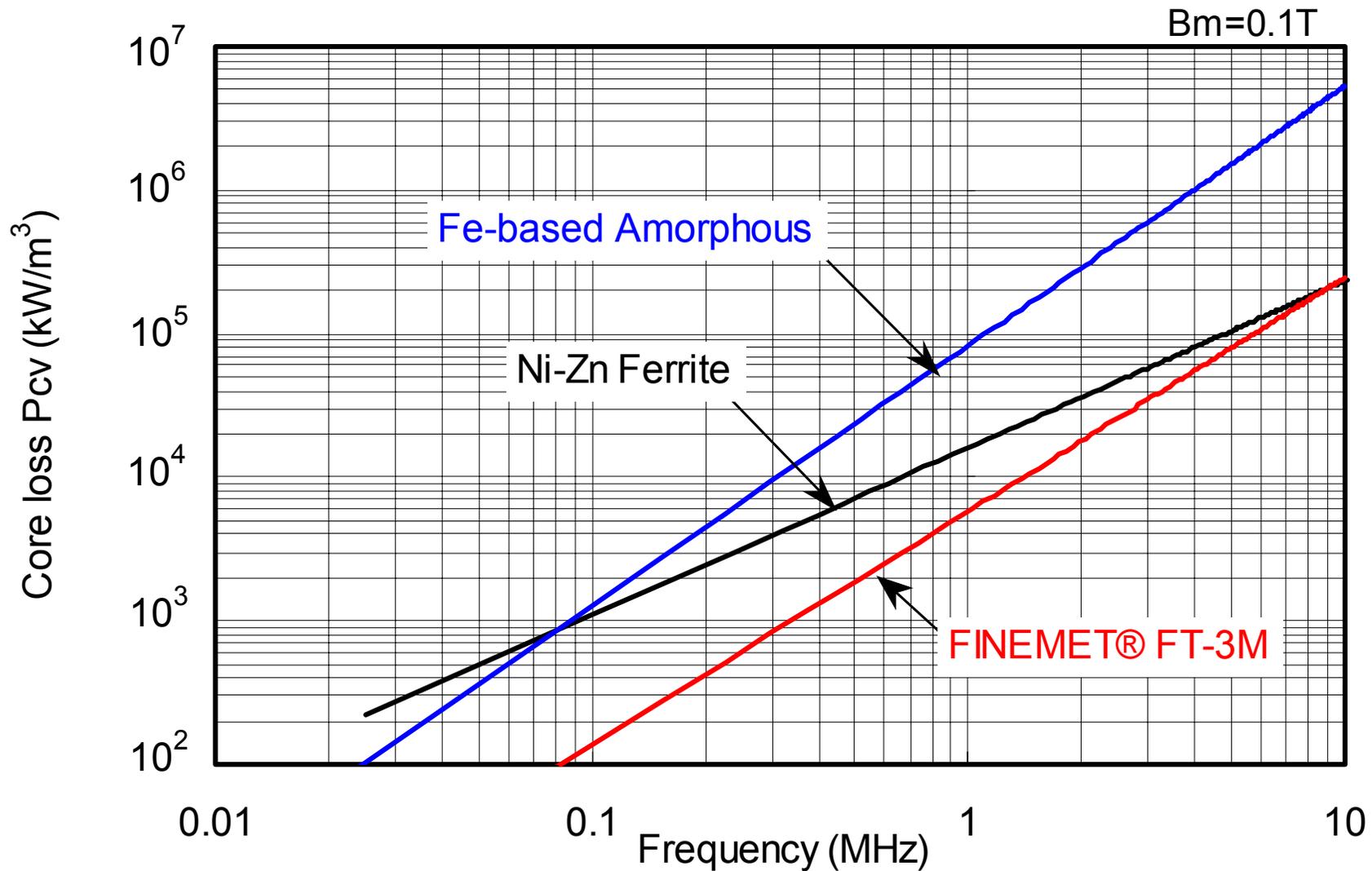


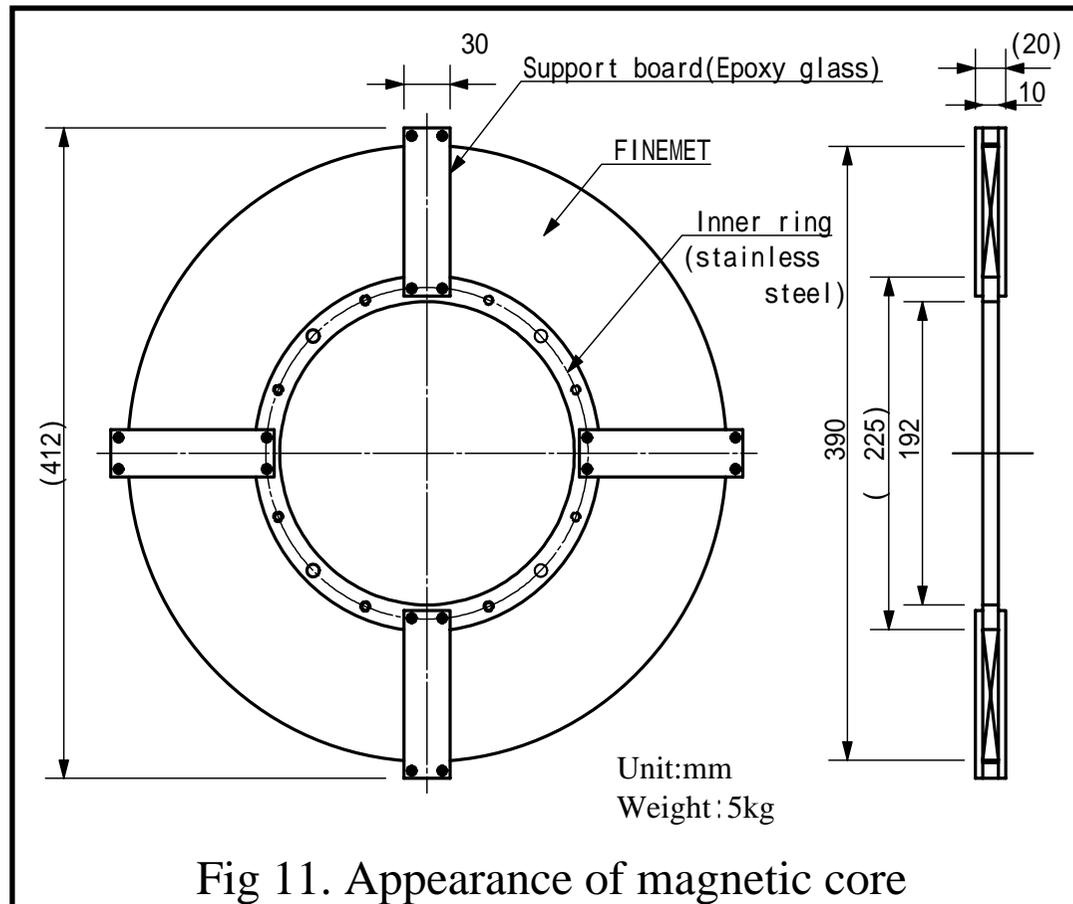
Fig 10. Comparison of Core loss characteristics.

Example of application for accelerator 3

Application : Accelerator cavity for Induction synchrotron

Customer : (KEK)

Appearance



Material :

FINEMET® FT-3M

(15 μ m)

Requirement:

lower core loss

Thin tape core characteristics



Table 4. μ Qf and Core loss comparison

Test core:
FT-3M 80- 50 × 10

	Thickness	μ Qf (× 10 ⁹)		Core loss (10 ³ × kW/m ³)*	
		1MHz	5MHz	1MHz	5MHz
Thin Tape	15 μ m	4.3	7.2	5.4	72.0
Standard Tape	18 μ m	3.8	6.4	6.1	79.9

*Bm=0.1T

Requirements of Magnetic cores for the acceleration cavity



Table 5. Requirements of Magnetic cores for the accelerator cavity

	FINEMET®	Ni-Zn Ferrite	Fe-based Amorphous
High B (T) *	(1.76)	× (0.65)	(2.04)
Low Core Loss** (× 10 ³ kW/m ³)	(6.1)	(16)	× (82)
High Curie temperature()	(> 570)	× (250)	(395)
High μ Qf *** (× 10 ⁹)	(4.3)	(34.7)	× (1.76)
Flux density dependence of μ Qf value		×	

:Excellent ; Good × :Bad

* Case of Induction cavity,pulse Transformer or MPC.

FINEMET:H(reset)=8A/m Ni-Zn Ferrite : H(reset)=160A/m ,Fe-based Amorphous :H(reset)=40A/m

** at 1MHz,Bm=0.1T

*** at 1MHz

Conclusion

Since FINEMET® has High B , Low core loss and Small Flux density dependence of μQf value, it is very sufficient as magnetic cores for accelerator cavities

12 % μQf increase and 10% core loss reduction are realized by applying FINEMET® thin tape

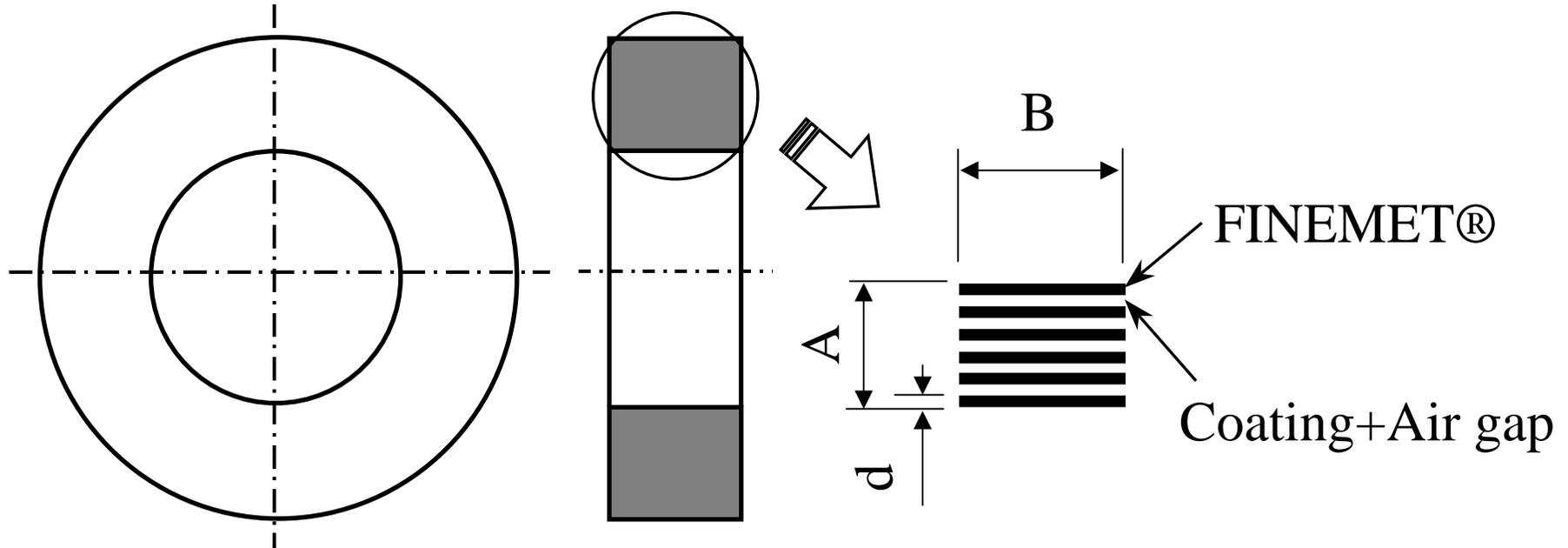
Future approach

Improvement of FINEMET® tape quality (Tape thickness and packing factor)



Materials Mag!c

About Packing factor



$$\text{Packing factor} = \frac{d \times N \times B}{A \times B}$$

N: Number of Layers.

Fig 12. About Packing factor

Magnetic properties of various materials.



Table 6. Magnetic properties of various materials.

	Bms (T)	Brms/Bms (%)	Hc (A/m)	μ_r (1kHz)	Curie temp. ()
FT-1H	1.35	90	0.8	5000	> 570
FT-3M	1.23	50	2.5	70000	> 570
Fe based Amorphous	1.56	66	5.0	4500	395
Ni-Zn Ferrite	0.38	65	60	250	250
Co based Amorphous	0.6	91	0.32	90000	180

Dynamic B-H Loops of FT-1H

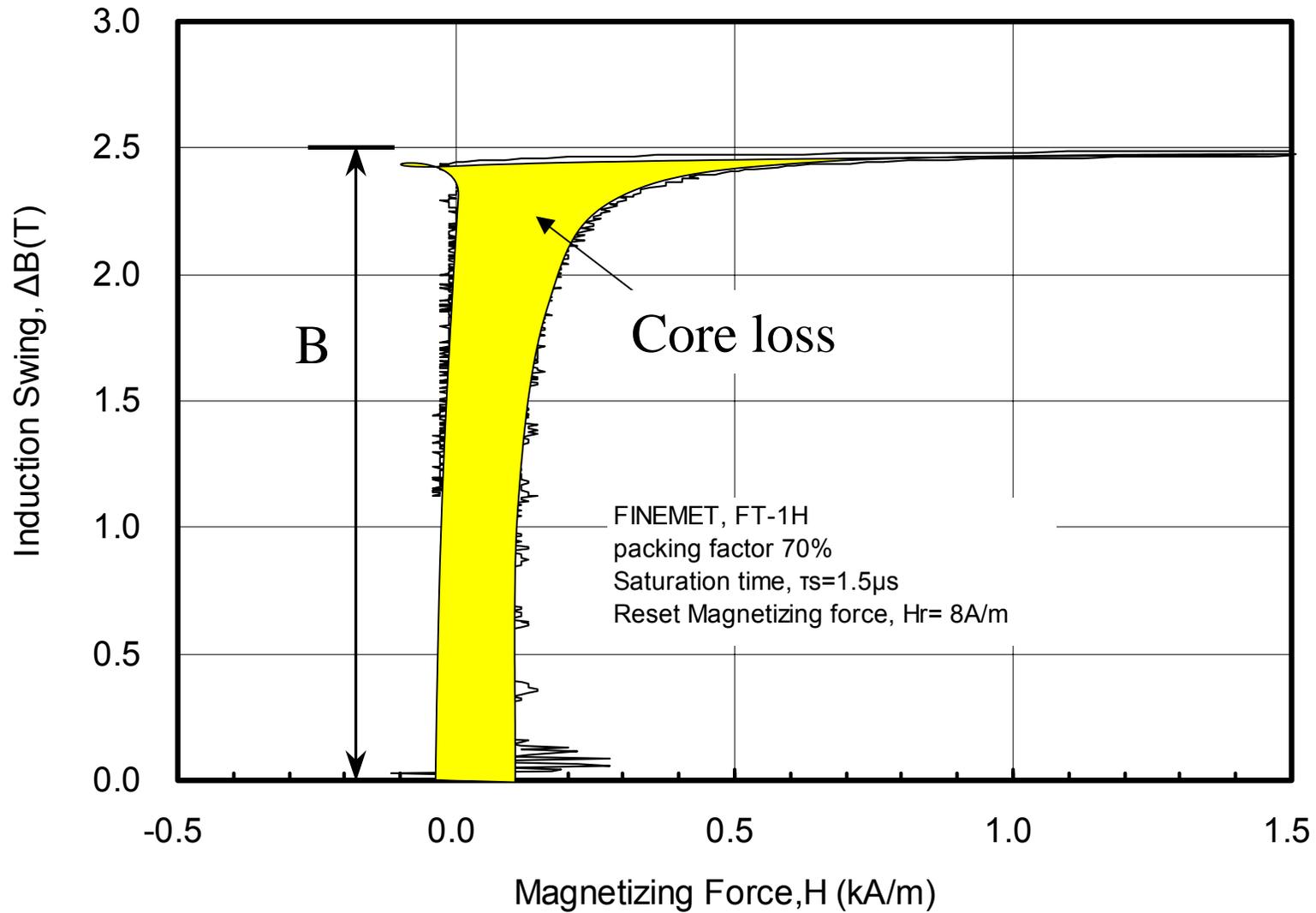


Fig 13. Dynamic B-H Loops of FT-1H core