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Development of iron-based composites with high thermal conductivity for DEMO

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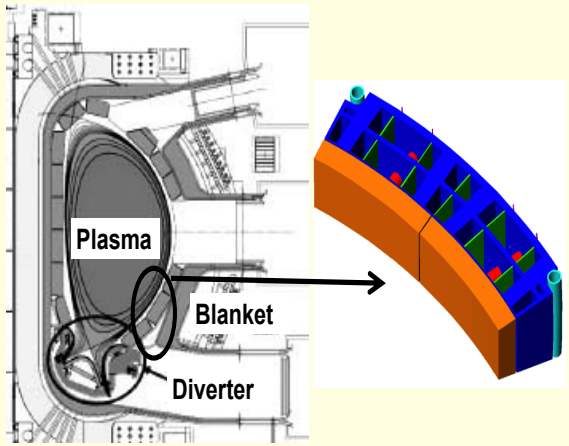
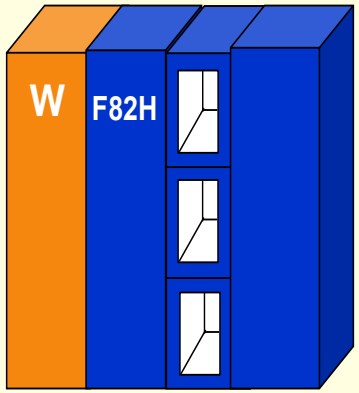
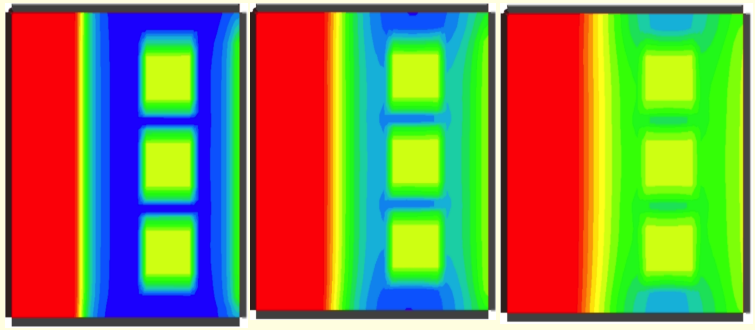
Candidate Materials for Diverter of DEMO



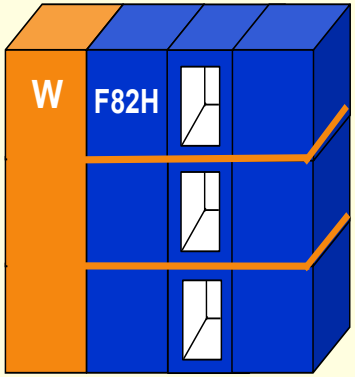
A Schema of Heat Transfer from PFM (500°C) to Coolant (300°C)



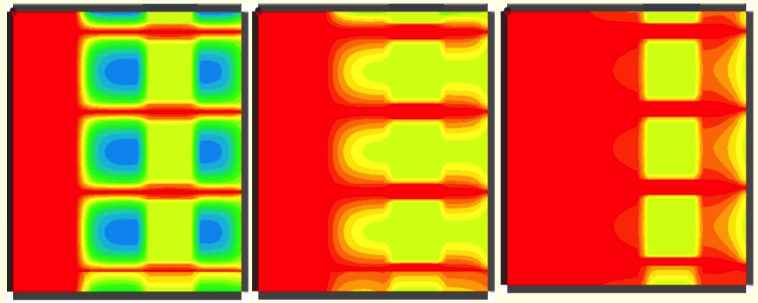
w/o Heat Sink



Temp. Gradient Exists between PFM and Coolant



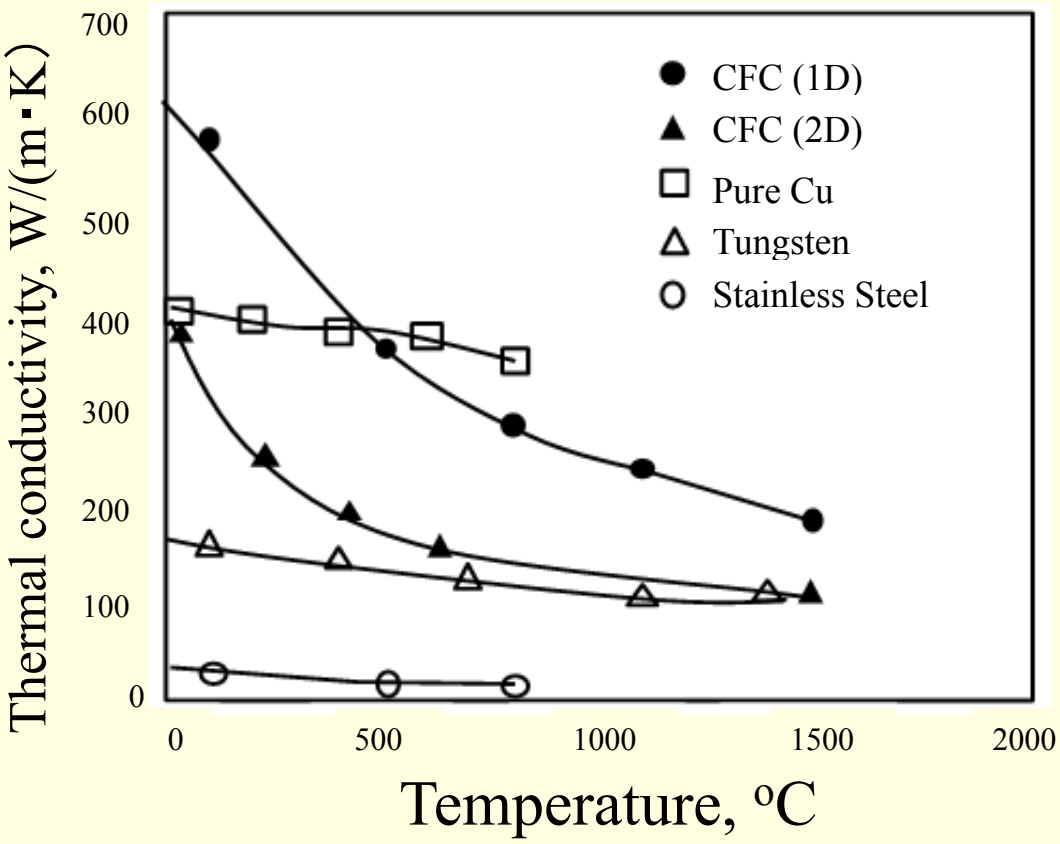
w/ Heat Sink



Little Temp. Gradient between PFM and Coolant

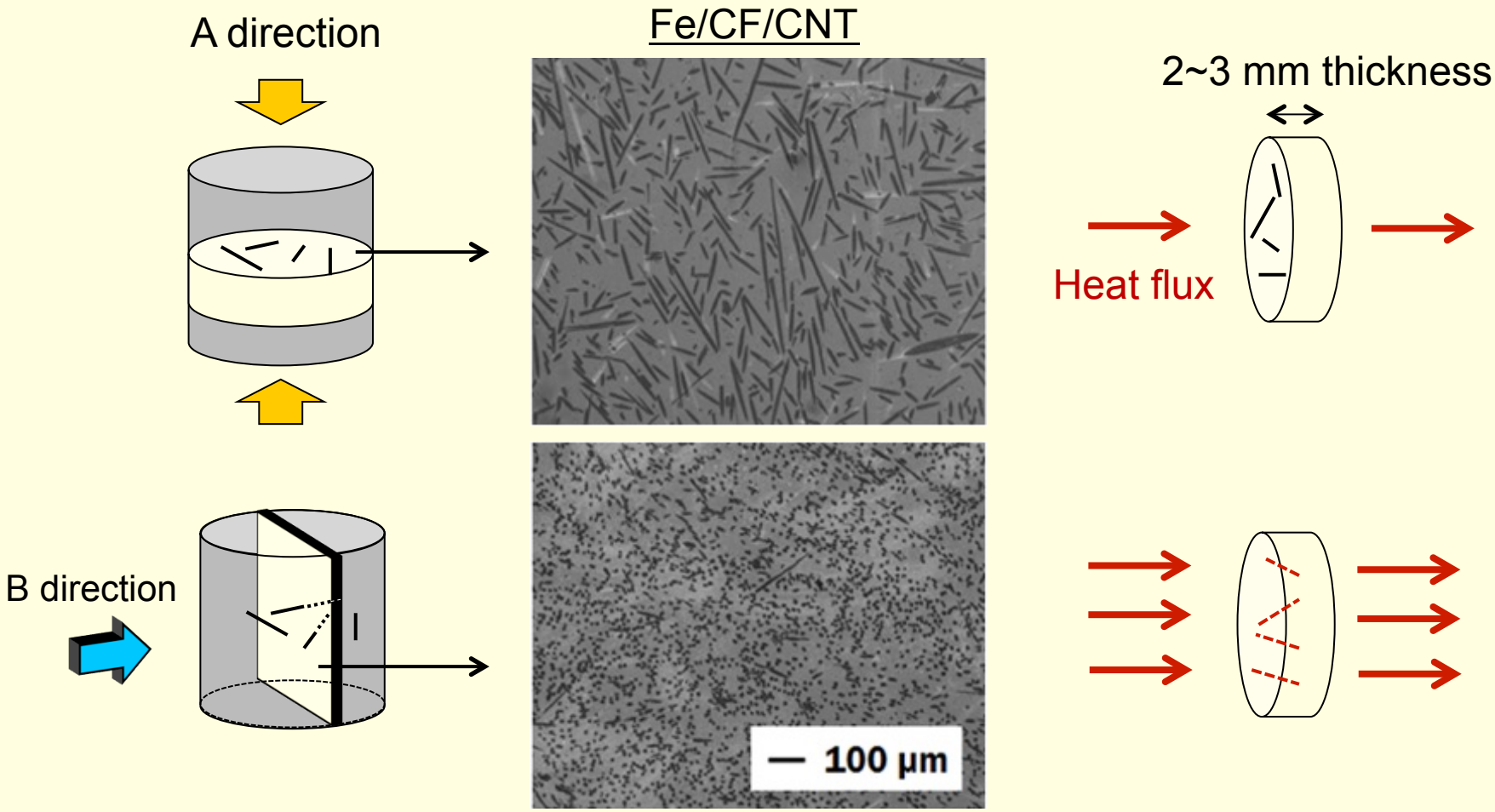
Comparison of Thermal Conductivity of Plasma Facing Materials

*J.Plasma Fusion Res.Vol82,No.10(2006) 699-706



Fe	45 W/m・K
F82H	22 W/m・K
Cf	550 W/m・K
CNT	1200 W/m・K

Use of CF and CNT for Improvement of Thermal Conductivity



2D alignment of CF and CNT by SPS

Improvement of Thermal Conductivity of Fe-based Composites

Matrix	Fe		**F82H**	
Direction	A	B	A	B
Bulk	70 ~ 80 W/m･K		30 W/m･K	
No additive	45.8		21.5	
30% CF + 0.2% CNT	48.8	127.7	18.4	38.9
	70%	**182%**	60%	**130%**

Fe/CF/CNT: 182%, F82H/CF/CNT: 130%

Objective

Investigating mechanical properties of Fe-Cf-CNT composite materials

- Nanohardness
- Vickers hardness
- Tensile strengths

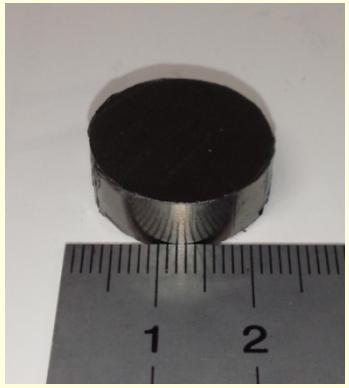
Experimental Procedure

Specimens
- **Pure Fe powder**
- **Fe-30%Cf-0.2%CNT**

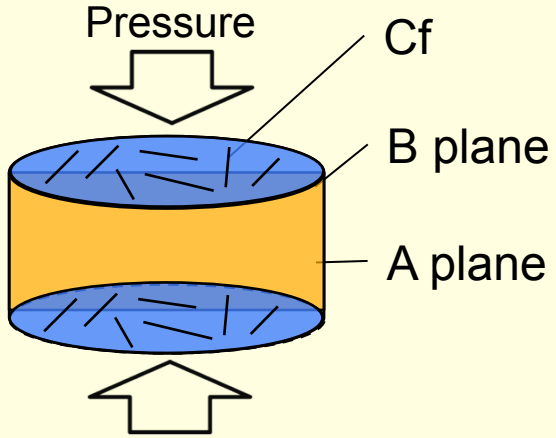
Sintering
- Pressure: 30 MPa
- Temperature: 950 ℃
- Holding time: 10 min

Cutting, polishing

Mechanical tests
- Nanohardness
- Vickers hardness
- Tensile

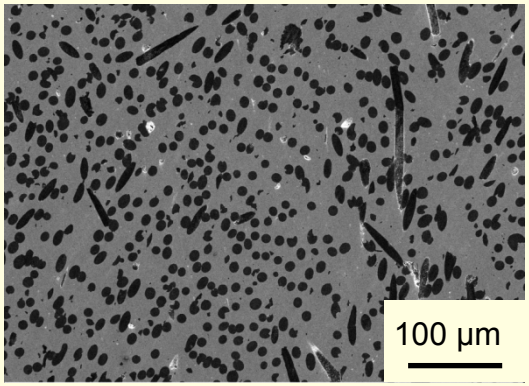


Sintered specimen

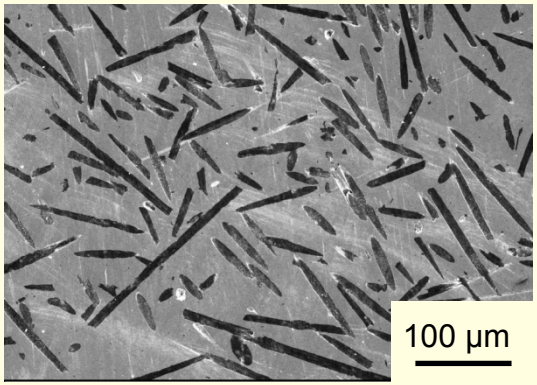


Cfs aligns on B plane.

SEM images of Fe-30%Cf composite



A plane



B plane

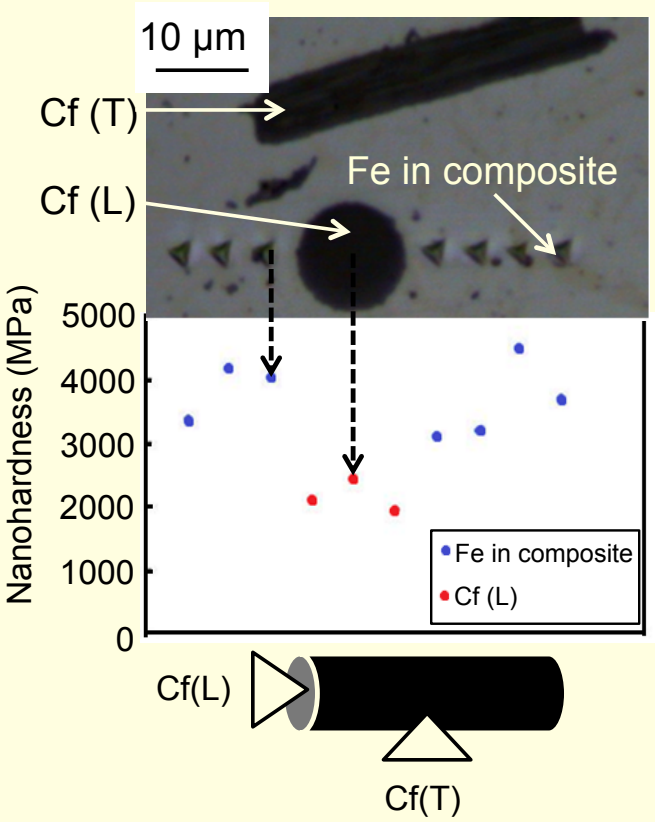
Results and discussion

Mechanical properties

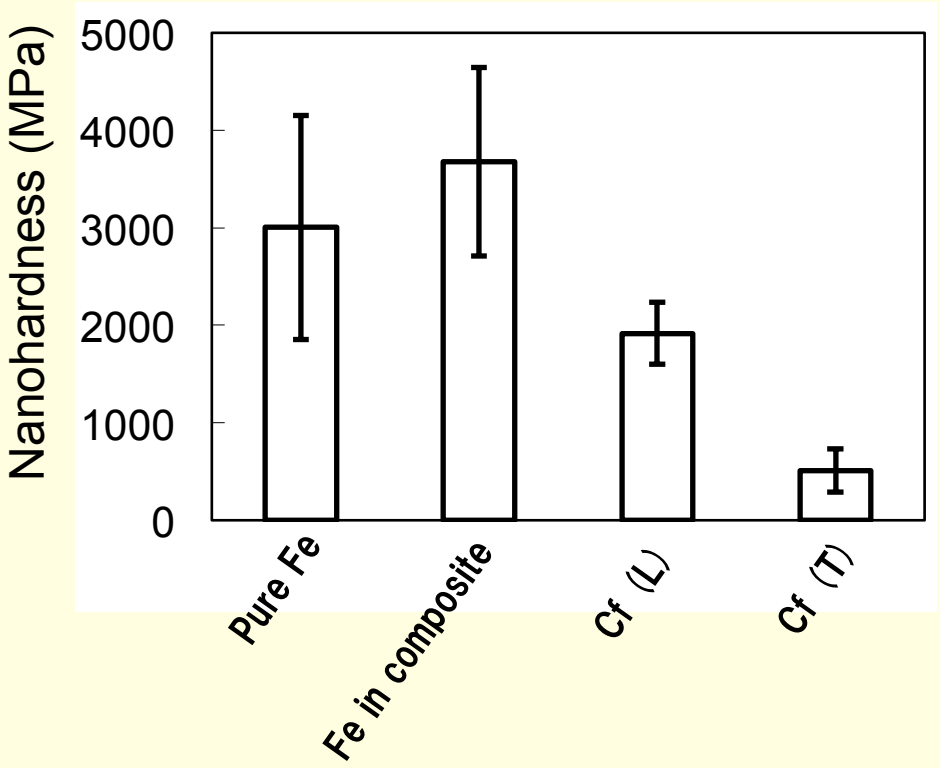
- Nanohardness
- Vickers hardness
- Tensile strengths

Results : Nanohardness

Indentation in Fe-30%Cf



Nanohardness of each specimen



- ✓ Nanohardness of Fe in composite was higher than that of pure Fe due to carburization during sintering.
- ✓ Cf (L) was harder than Cf (T).
- ✓ Cf was much softer than Fe and Fe composite.

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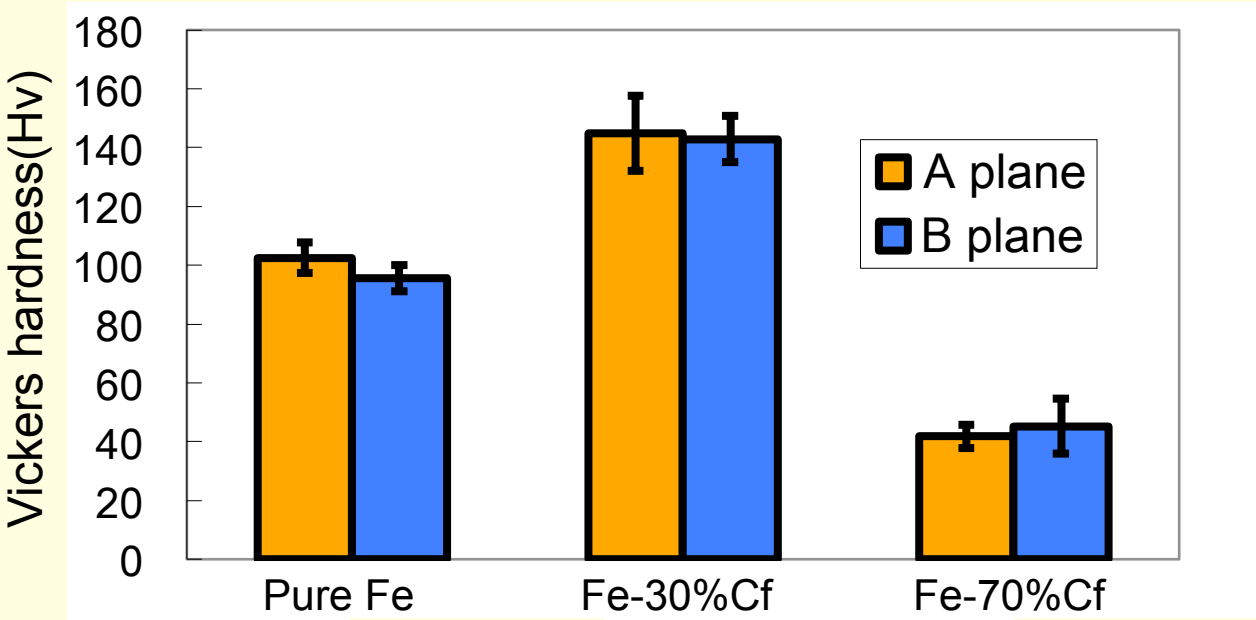
Results and discussion

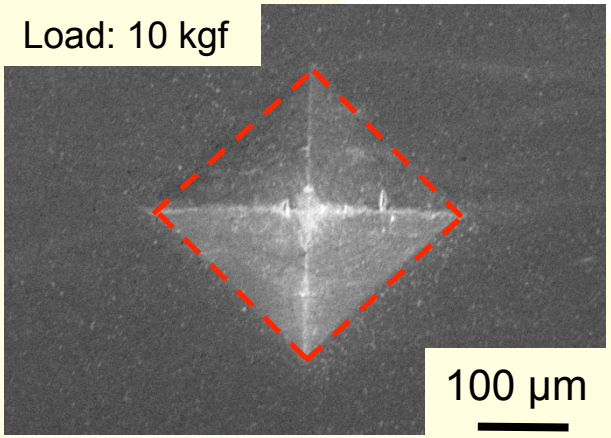
Mechanical properties

- Nanohardness
- Vickers hardness
- Tensile strengths

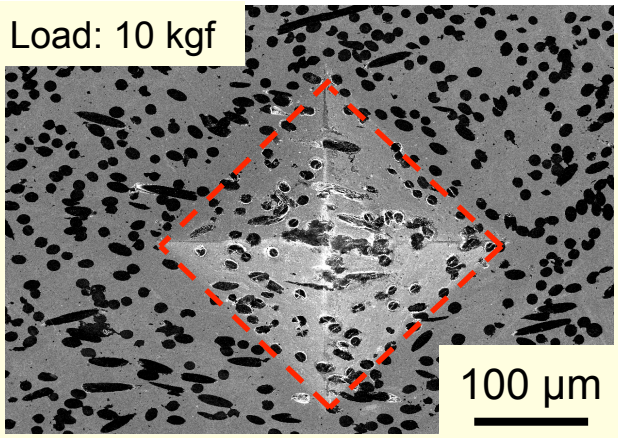
※Fe-70%Cf composite was also tested.

Result : Vickers hardness

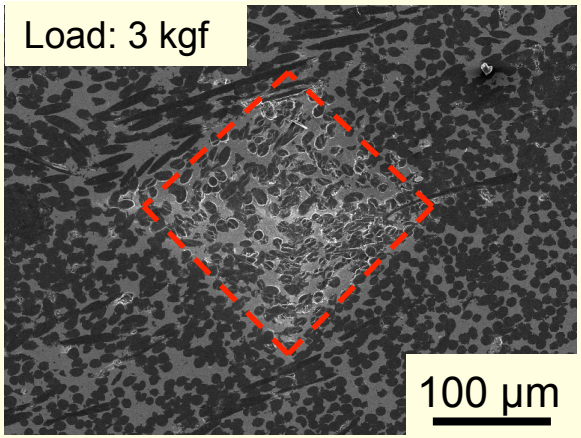




S_{Cf}/S_{total}=0



S_{Cf}/S_{total}=0.23



S_{Cf}/S_{total}=0.63

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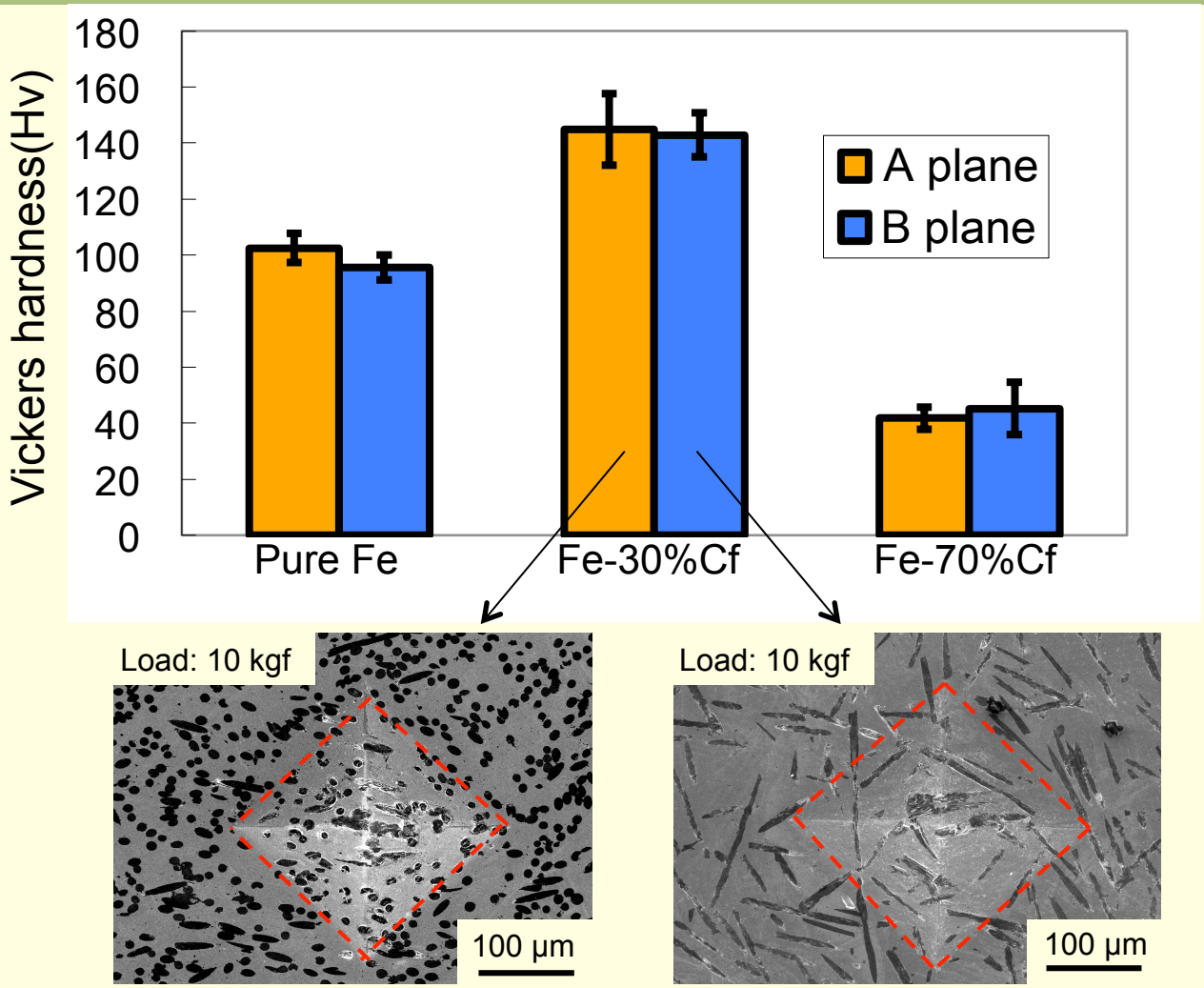
Result : Vickers hardness



S_{Cf}/S_{total}=0.23

S_{Cf}/S_{total}=0.22

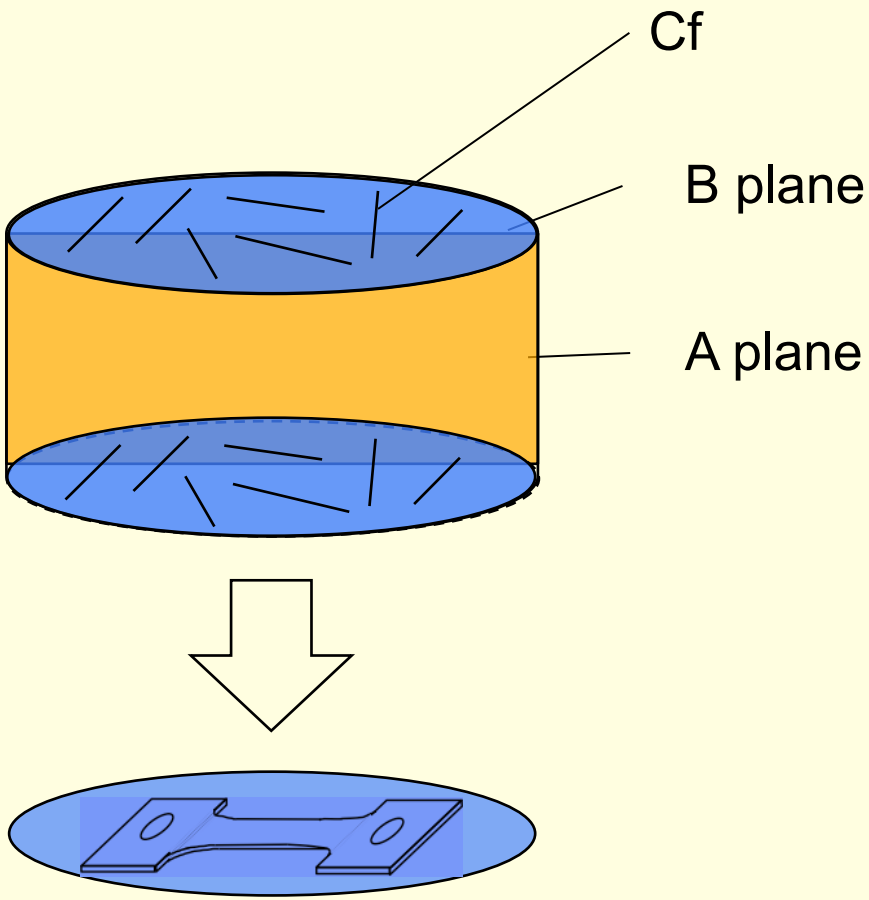
Results and discussion

Mechanical properties

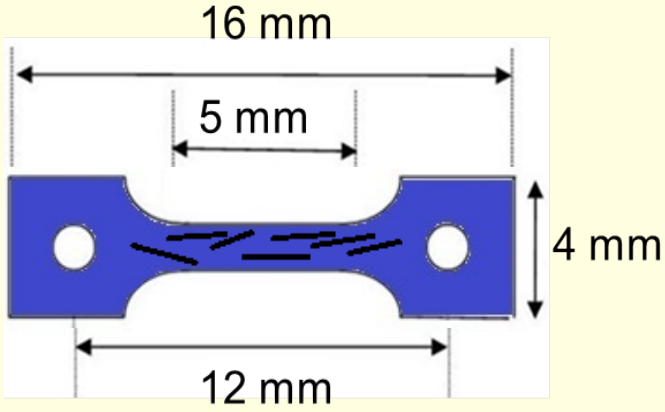
- Nanohardness
- Vickers hardness
- Tensile strengths

Experimental of Tensile test

Fabrication of tensile specimen



Dimension of test specimen

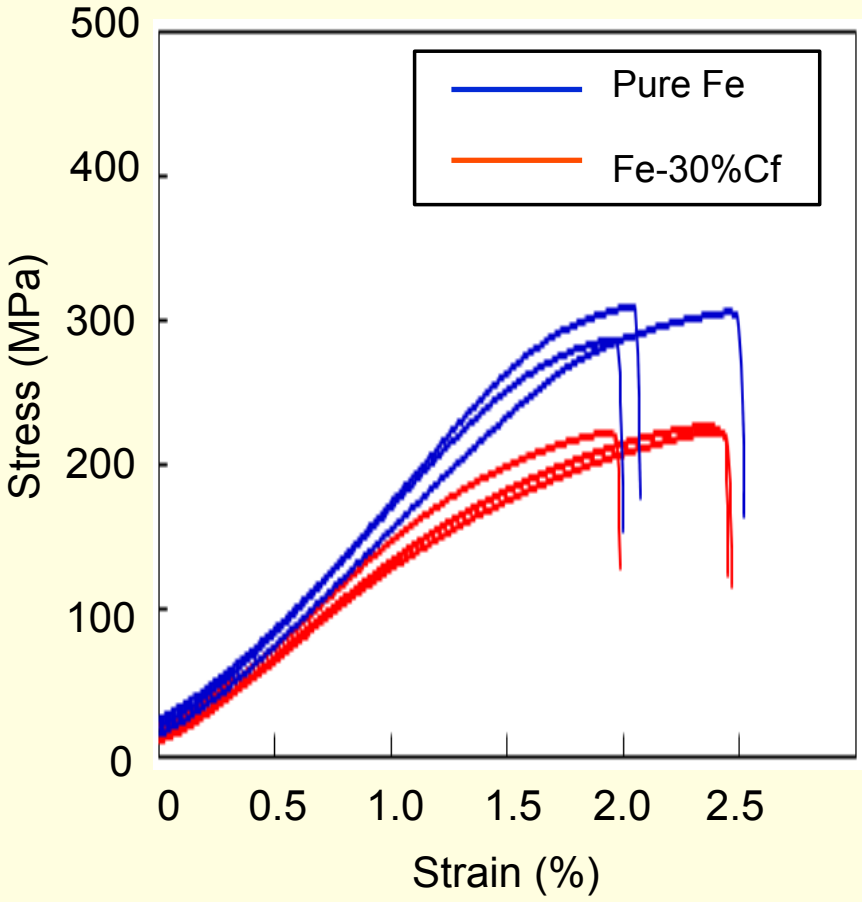


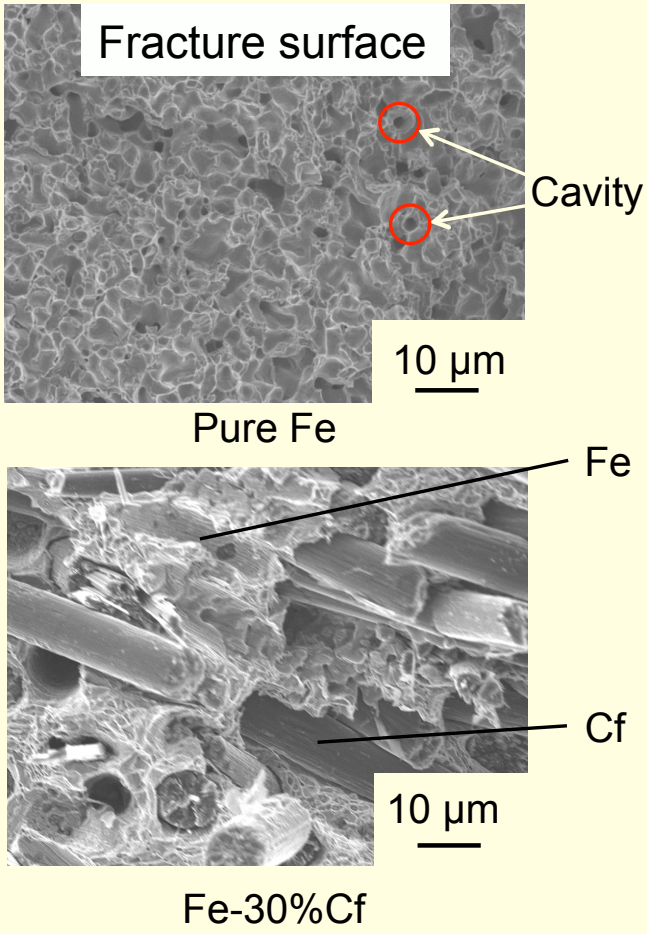
Thickness: 0.3~0.8 mm

Test condition

Temperature	RT
Atmosphere	Air
Strain rate	10^{-3} s^{-1}

Result : Tensile properties





✓ **Strength decreased due to weak bonding between Fe and Cf.**

Summary

Nanohardness

- ✓ Nanohardness of Fe in composite was higher than that of pure Fe because of carburization during sintering.

Vickers hardness

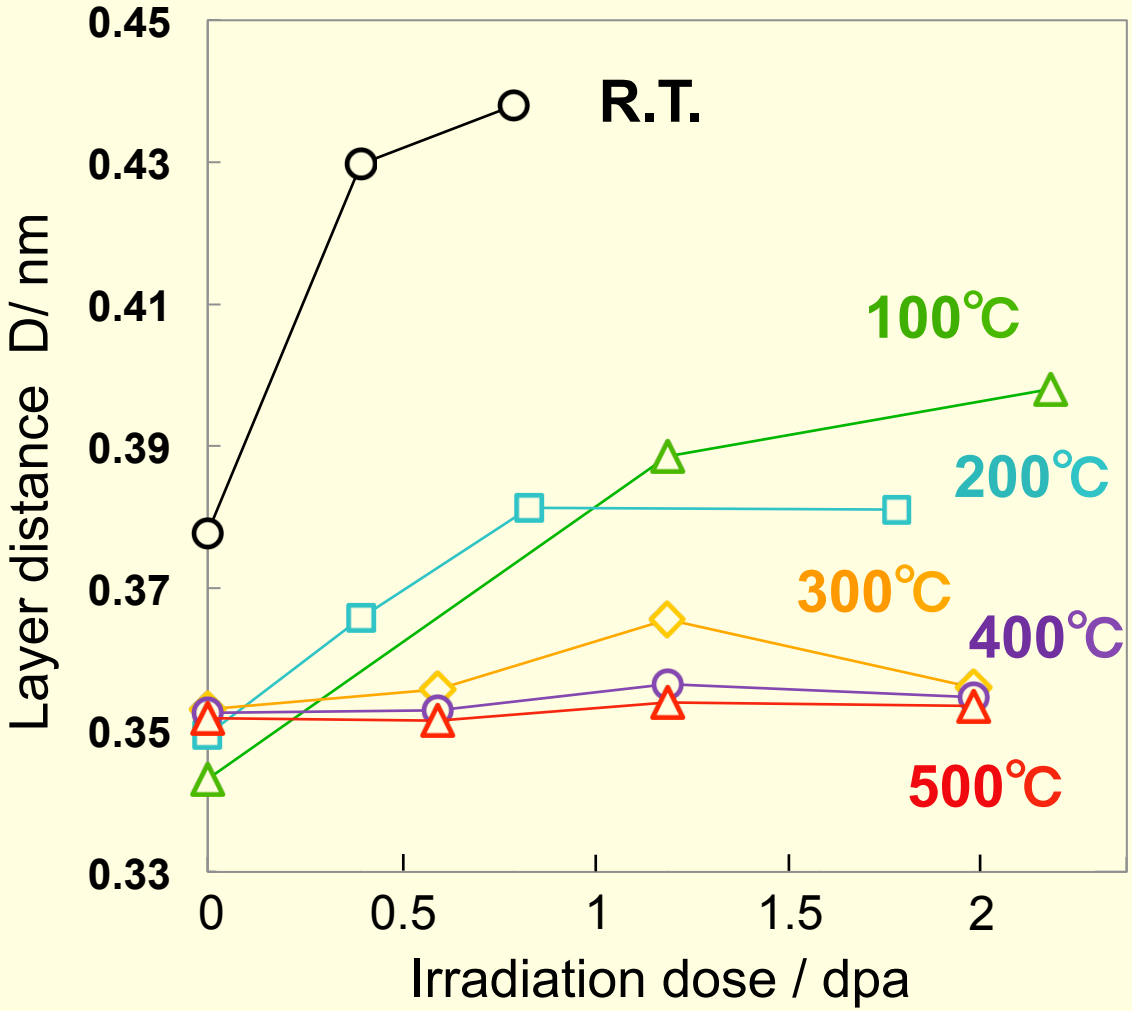
- ✓ Vickers hardness reflected Cf area fraction in the tip area.

Tensile strengths

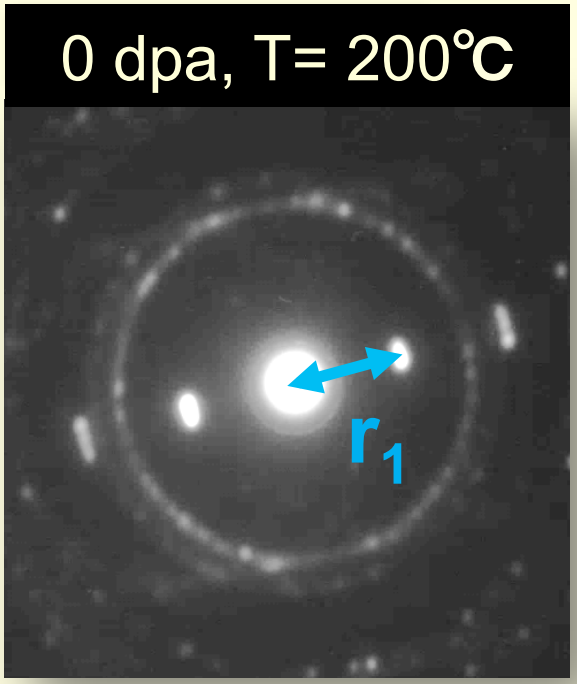
- ✓ Tensile strength of Fe-30%Cf composite was lower than that of pure Fe because of weak bonding between Fe and Cf.

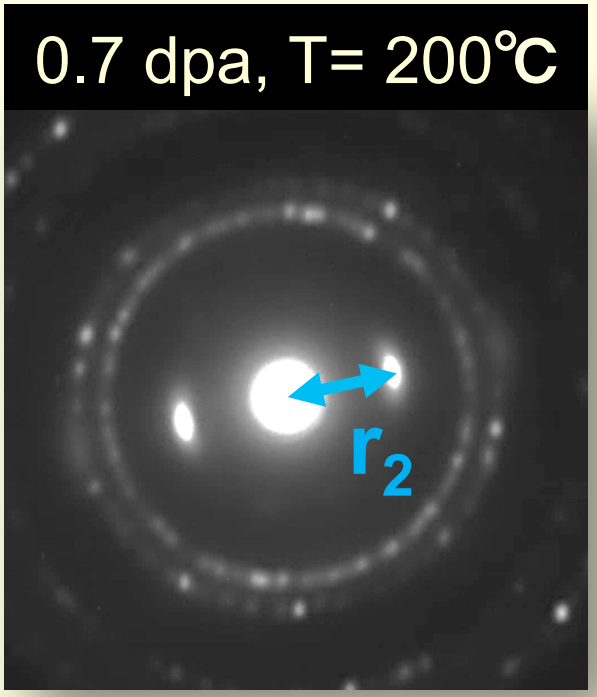
Optional Slides

Change in the layer distance of MWCNTs



Change in the layer distance of MWCNTs





$$r_1 > r_2$$