

111-P Effect of electrical properties on lightning damage behavior of CFRP

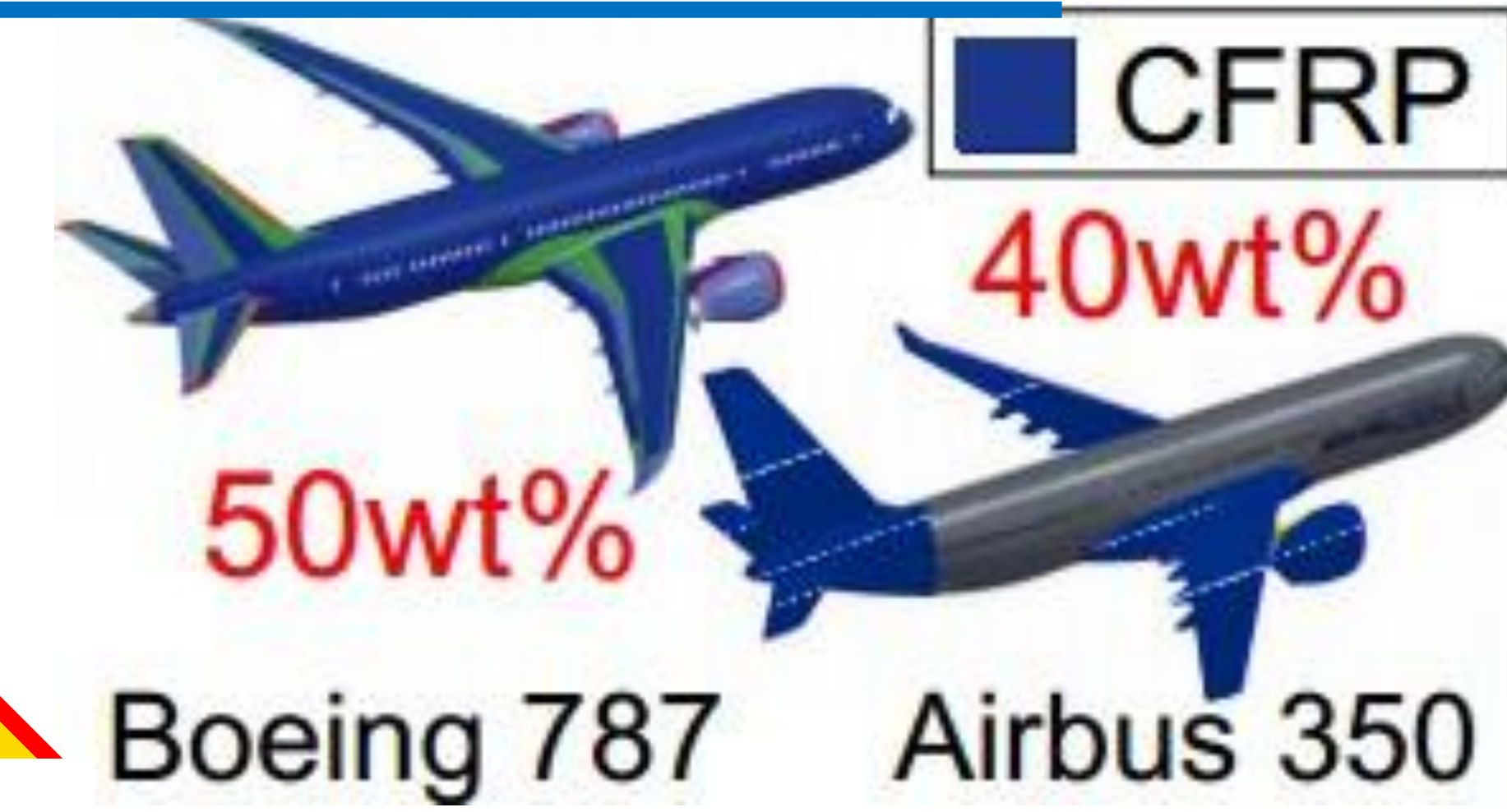
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Expansion of applying CFRP to aircraft

CFRP(Carbon Fiber Reinforced Plastic)

- Lightweight
- High strength
- High fatigue strength

Applying to aircraft Struck by lightning



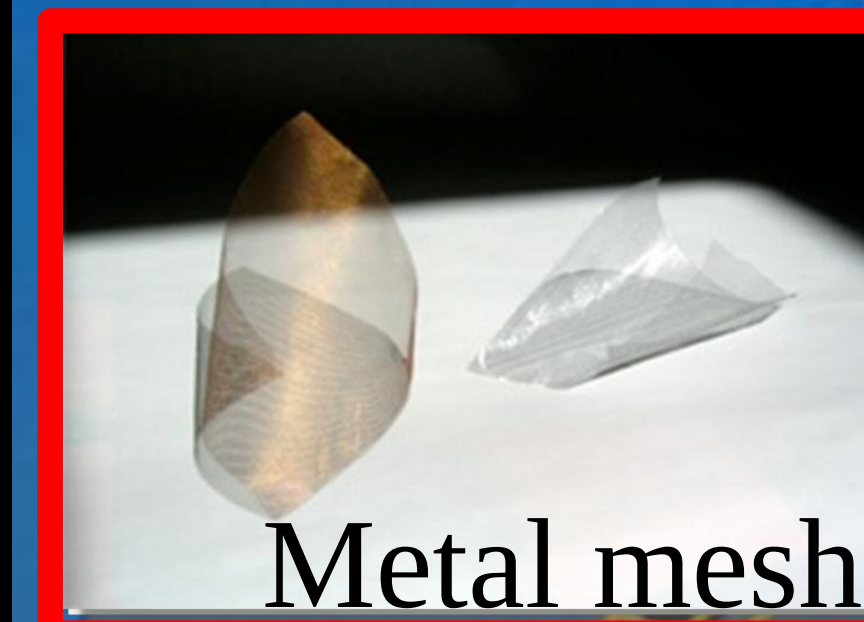
✓ One lightning strike per aircraft per year.

Electrical Resistivity [Ωmm]

Duralumin	CFRP (Direction of thickness)
4.0×10^{-11}	$7.3 \times 10^9 \rightarrow 2.9 \times 10^{-1}$

Lightning protection system is required

Attaching metal mesh on CFRP to escape current



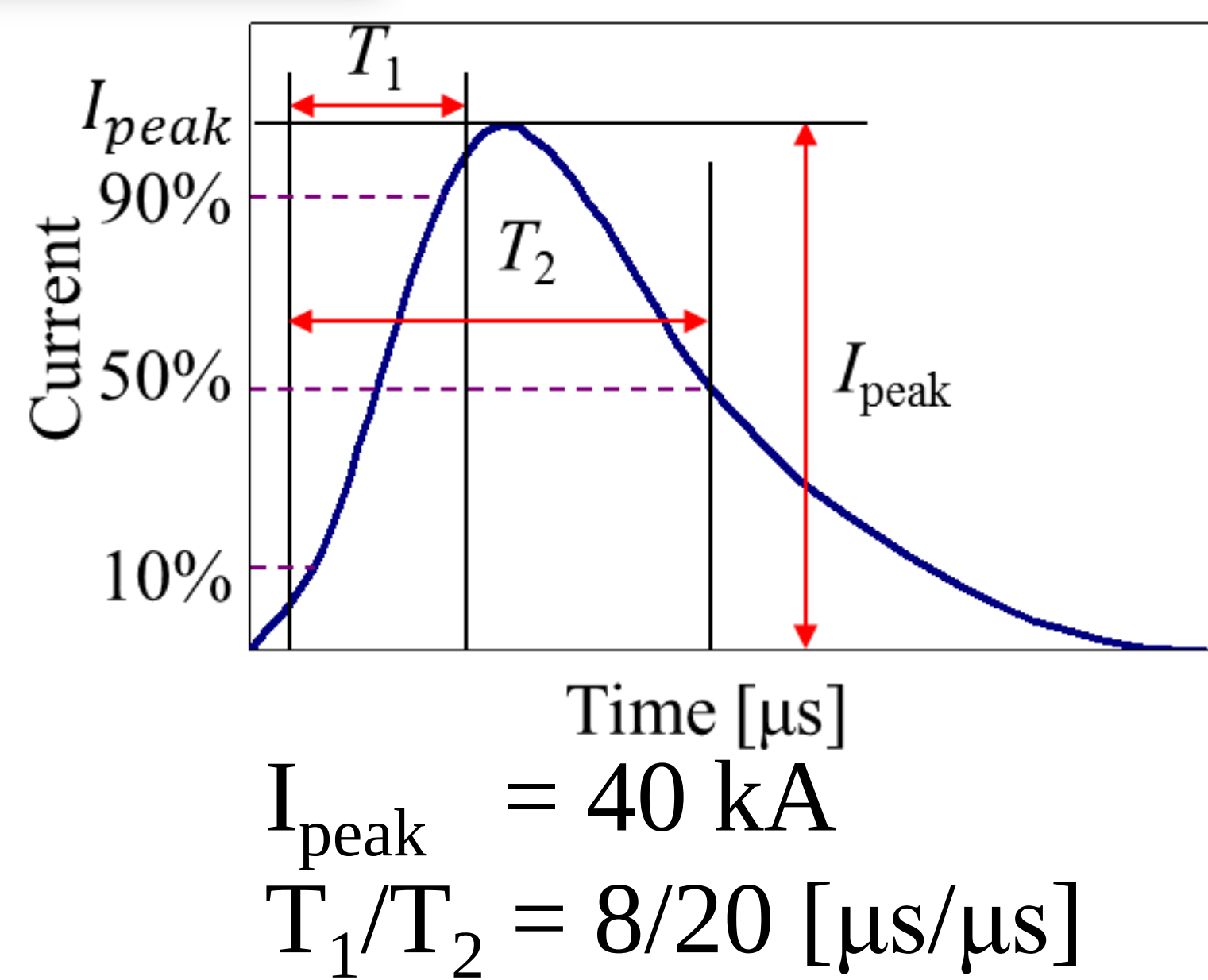
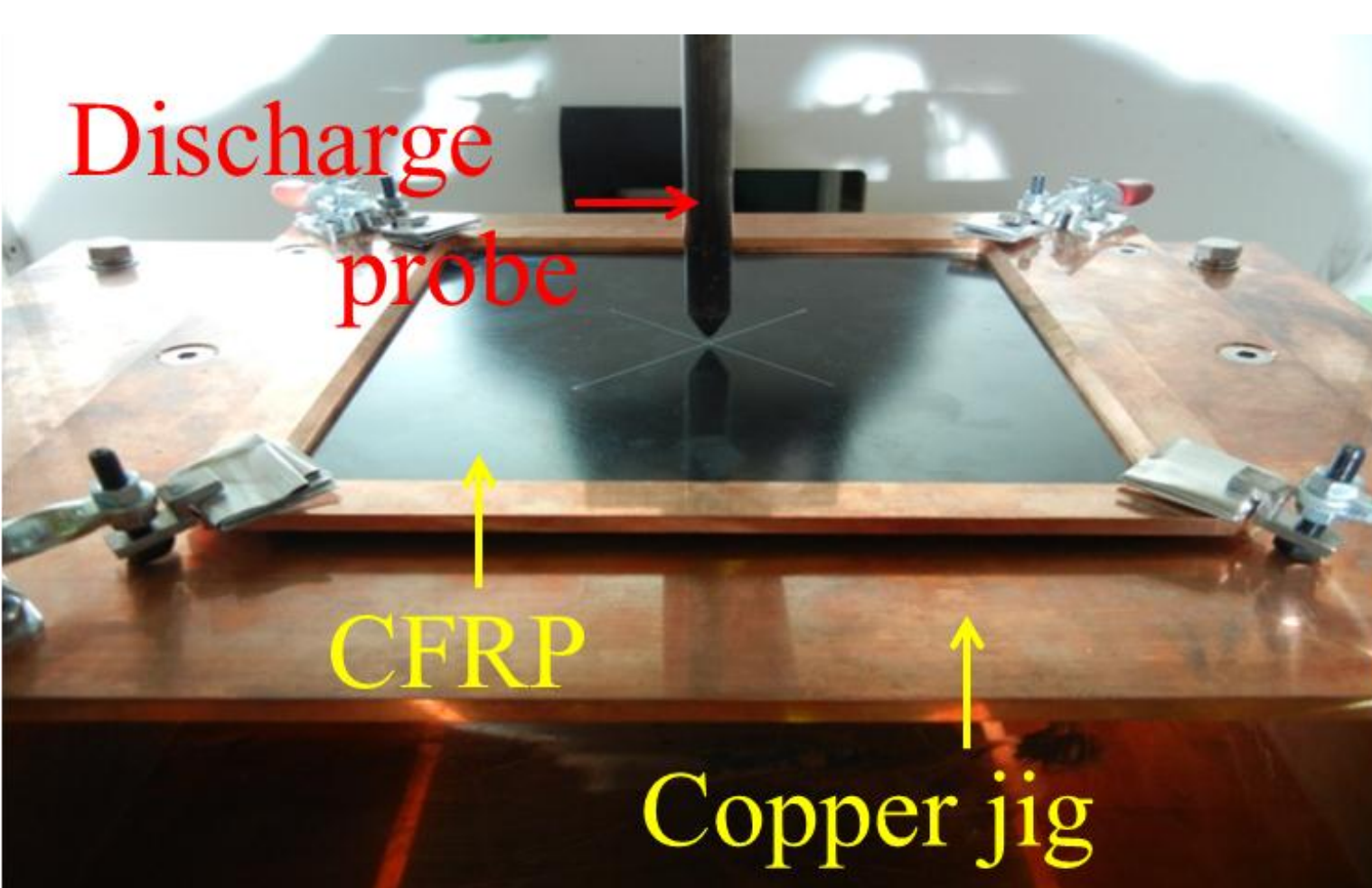
But...

- Increase the manufacturing steps
- Weight increase etc...

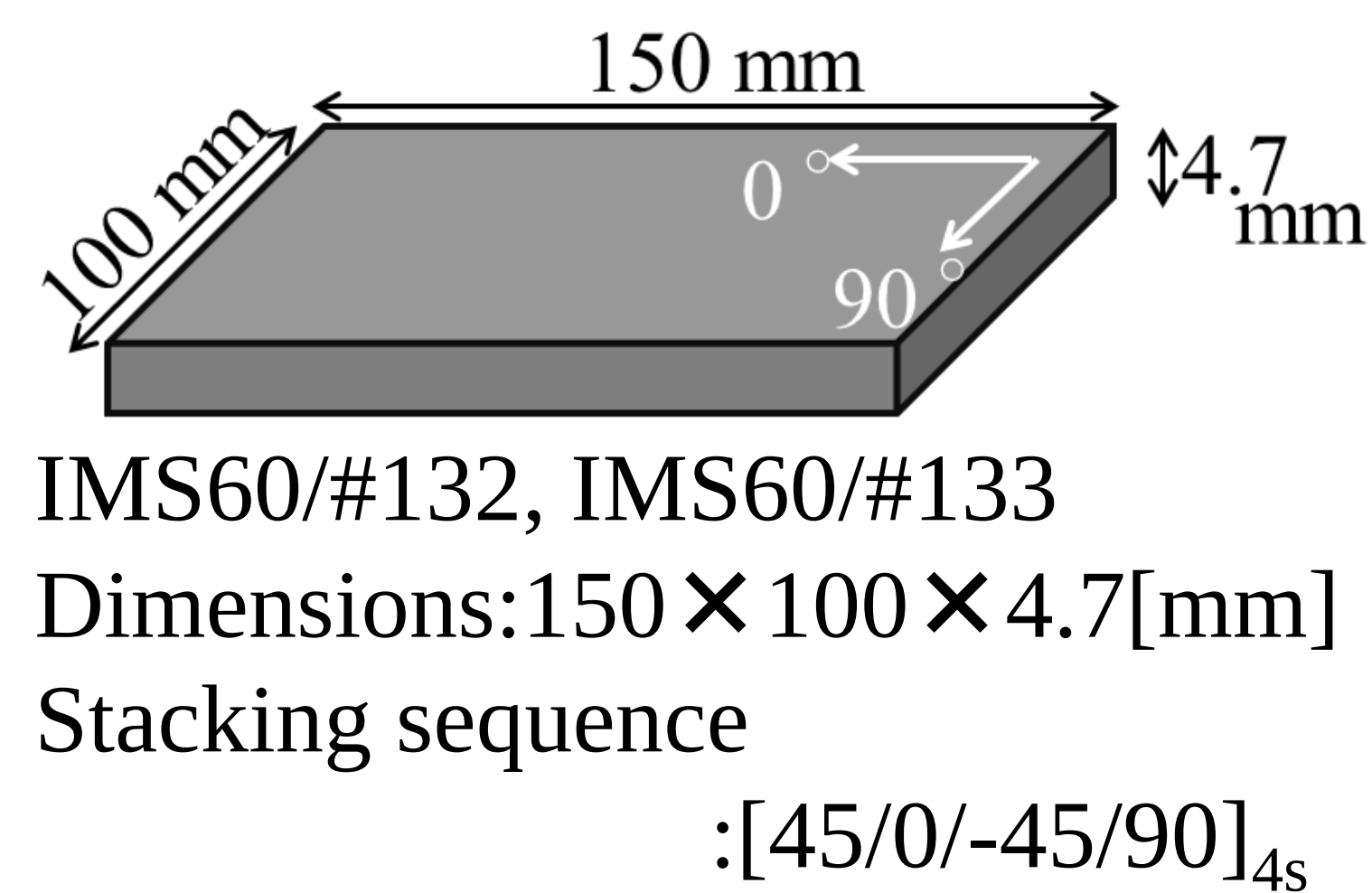
Need to study the lightning damage of CFRP

Artificial lightning testing

Test condition



Specimen



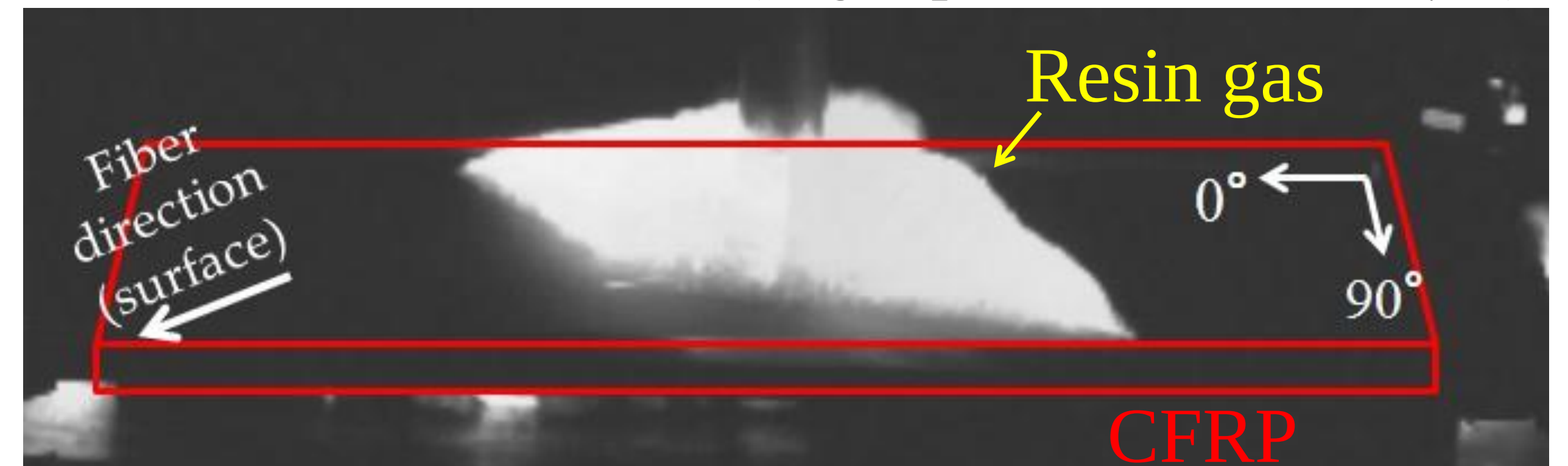
Electrical Conductivity

$[(\Omega\text{mm})^{-1}]$	IMS60/#132	IMS60/#133
Longitudinal	14.9	16.6
Transverse	1.38×10^{-3}	6.93×10^{-4}
Thickness	1.15×10^{-4}	3.44×10^{-6}

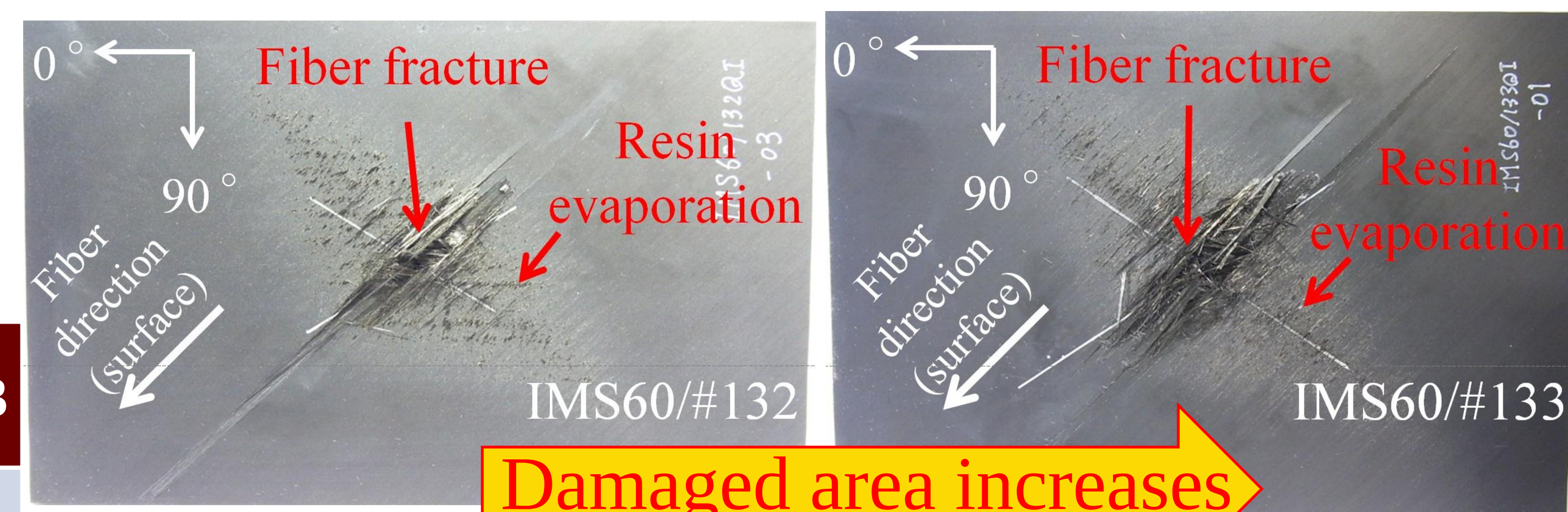
Resistance increases

Test results

(High speed camera [at 10μs])



Gasification of the resin along transverse direction

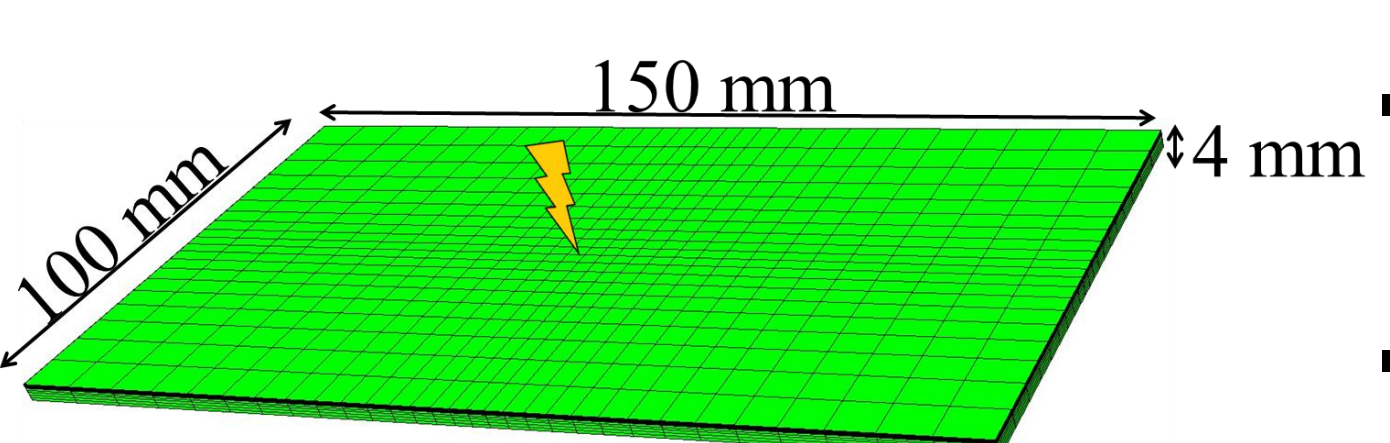
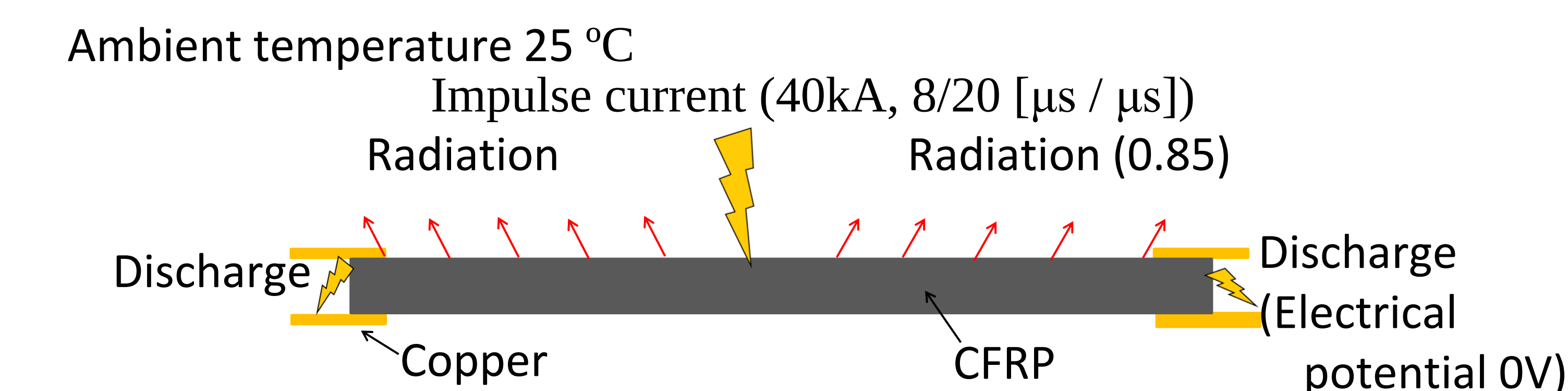


Damaged area increases

Longitudinal: Fiber fracture
Transverse: Resin gasification

Coupled thermal–electrical analysis

Boundary condition

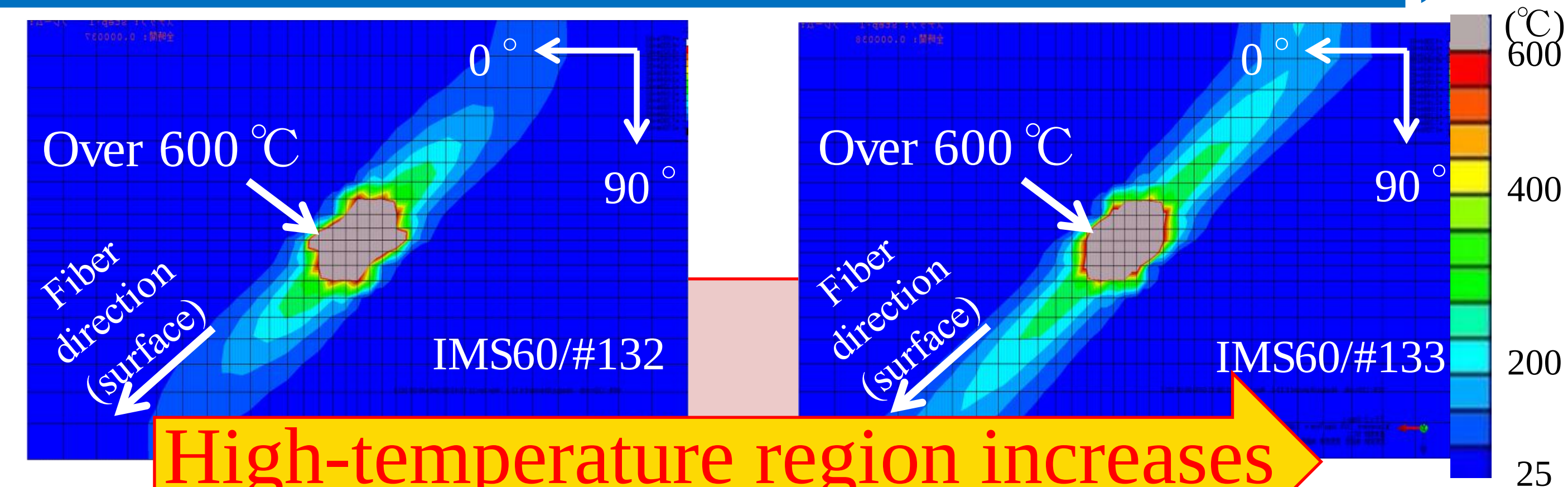


- Conductivities increases in 300 ~ 600 °C (The resin starts to evaporate at 300 °C)
- Large latent heat at 4000 °C (Carbon sublimates at 3900 ~ 4200 °C)

- Dimensions : 150 × 100 × 4 [mm] (1ply 0.125 mm thickness)
- Stacking sequence : [45/0/-45/90]_4s
- Element type : hexahedron ,8 nodes
- Element count : 6000 nodes

	IMS60/	#132	#133
Specific heat [J/kg]		1065	1065
Density [kg/mm3]		1.54×10^{-6}	1.52×10^{-6}
Thermal conductivity [W/mm/K]	Longitudinal	14.9	16.6
	Transverse	1.38×10^{-3}	6.93×10^{-4}
	Thickness	1.15×10^{-4}	3.44×10^{-6}

Analysis results (Temperature distribution)

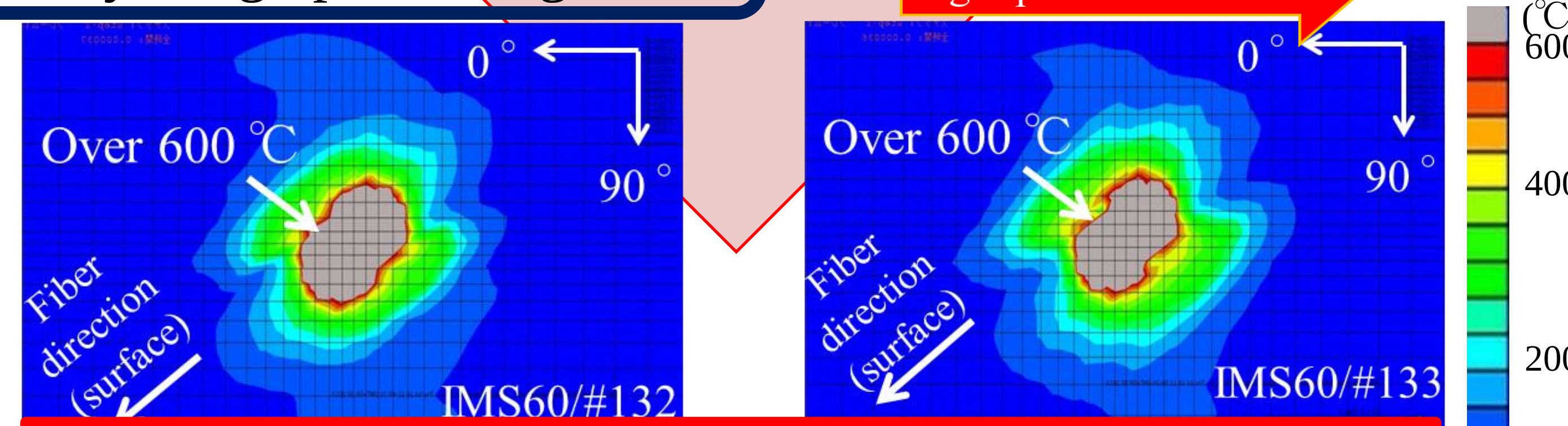
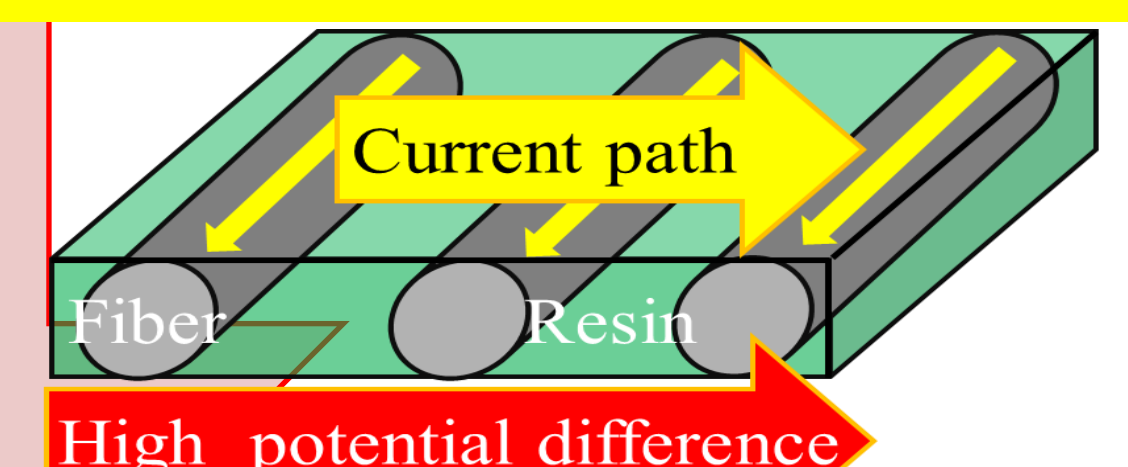


High-temperature region increases

Temperature does not rise to the transverse direction

Electrical breakdown

Insulating state is destroyed by a high potential gradient.



Breakdown is one of the causes of gasification to the transverse direction.

