98-P

Experimental Evaluation of Interfacial Fracture Toughness of Composite/Adhesives Treated by In-mold Surface Modification

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Background

TORAY “TEEWAVE” AR1

Application of CFRP to automobiles

Necessity of high productivity

Adhesive bonded joint of composite structures

Weight reduction
Avoid stress concentration

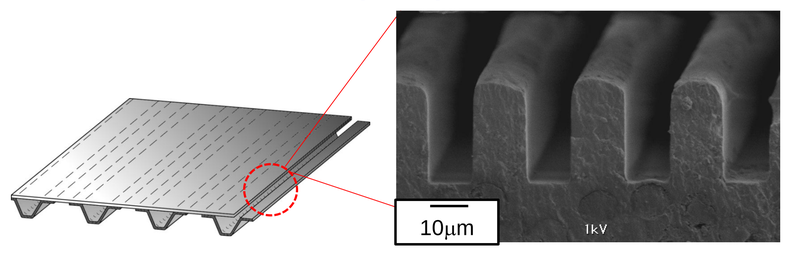
Sandblasting

Conventional surface preparations for composite

Sandblasting, chemical etching etc.

Problems
- ✓ Increase manufacturing process
- ✓ Worsen working environment
- ✓ Unsuitable for controlling adhesive properties

In-mold surface preparation



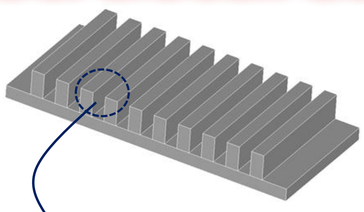
Panel-stiffener structure

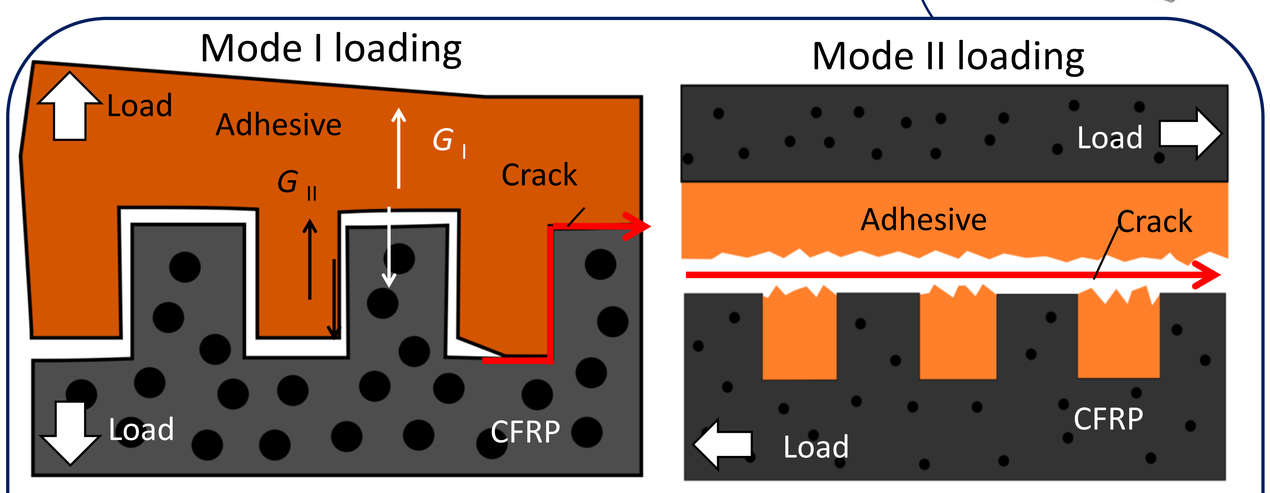
Merits
- ✓ Save processing
- ✓ Improving working environment
- ✓ Controlling adhesive properties

Micro concavo-convex structures

Fracture toughness

Mode II (G_{IIC}) ＞ Mode I (G_{IC})
Cohesive failure ＞ Interfacial failure





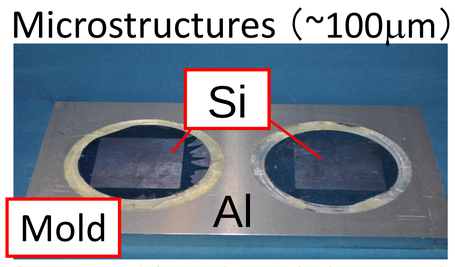
Introduction of mode II fracture region

Interfacial + cohesive failures

Resistance of crack propagation can be improved in both cases.

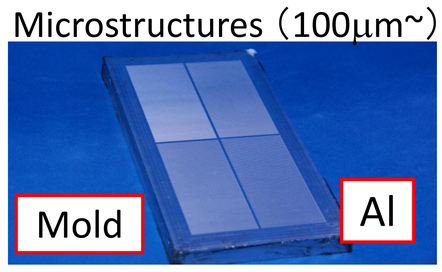
In-mold surface preparation

Microstructures（~100μm）

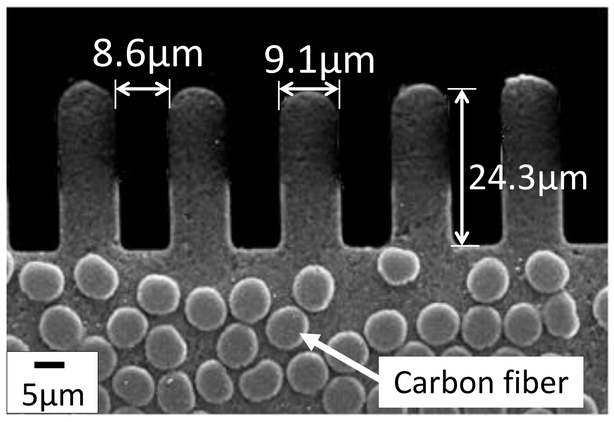


Fabricated by photolithography

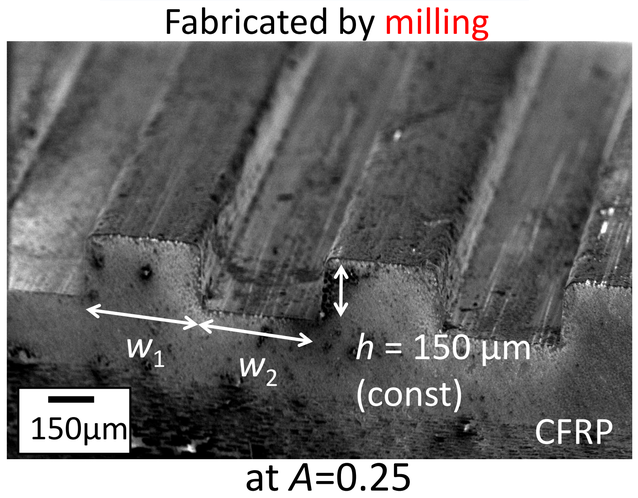
Microstructures（100μm~）



Fabricated by milling



at A=1.37



at A=0.25

Various sizes of microstructures can be transferred

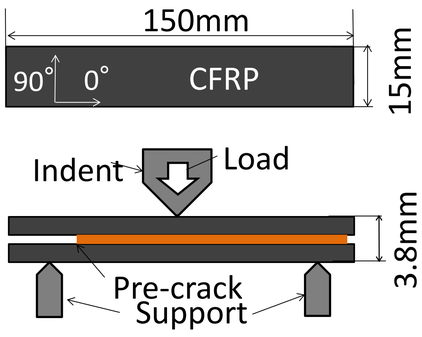
Aspect ratio of concavo-convex

$$A = \frac{h}{w_1 + w_2}$$

Width and depth :$w_1 = w_2$, h = 150 μm(const)
Aspect ratio: A = 0(flat) , 0.13, 0.15, 0.19,and 0.25

Experiments

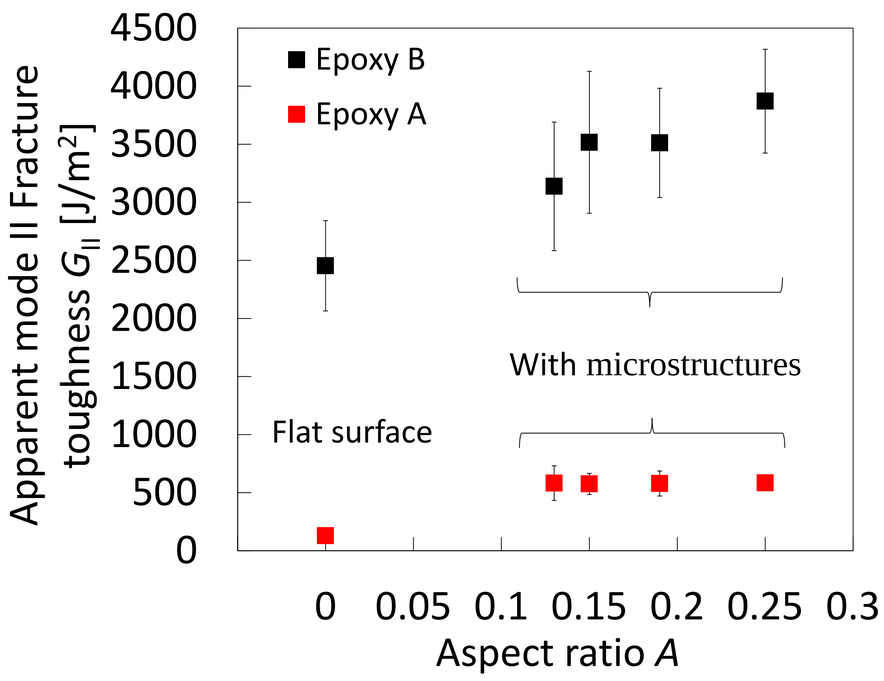
ENF（End Notched Flexure) tests, JIS K7086



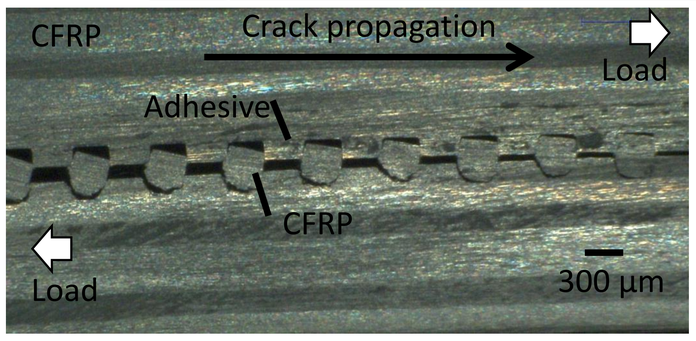
Schematic of ENF specimen

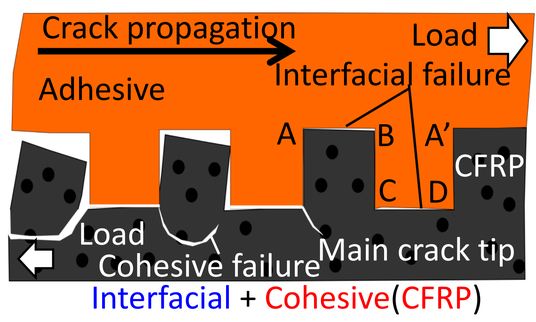
$$G_{II} = \frac{9a_1^3 P_c^2 C}{2B(2L^3 + 3a_1^3)}$$

L:Half span of the supports [mm]
B:Width[mm]
P_c: Load [N]
C: Load point compliance [mm/N]
a_1:Estimated crack length [mm]



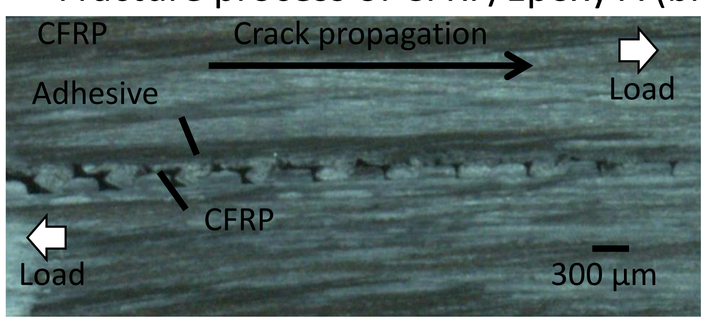
Fracture behavior around main crack tip

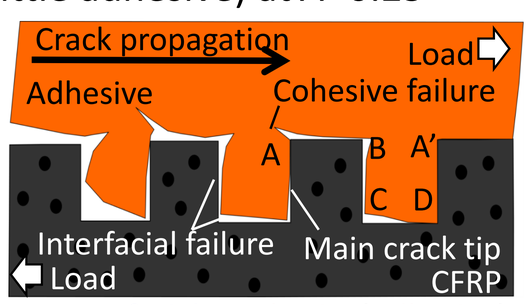




Interfacial + Cohesive(CFRP) failures

Fracture process of CFRP/Epoxy A (brittle adhesive) at A=0.25





Interfacial + Cohesive(Adhesive) failures

Fracture process of CFRP/Epoxy B (ductile adhesive) at A=0.25

Conclusions

- ✓ In both types of adhesives, GII of CFRP/Adhesive were improved by in-mold surface preparation.
- ✓ For practical application, suitable adhesive must be applied depending on composite structures, because different fracture behaviors were shown according to mechanical properties of the adhesives.