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DETECTING CRACK EXTENSION USING ALIGNED GRAPHENE IN SINGLE LAP JOINT

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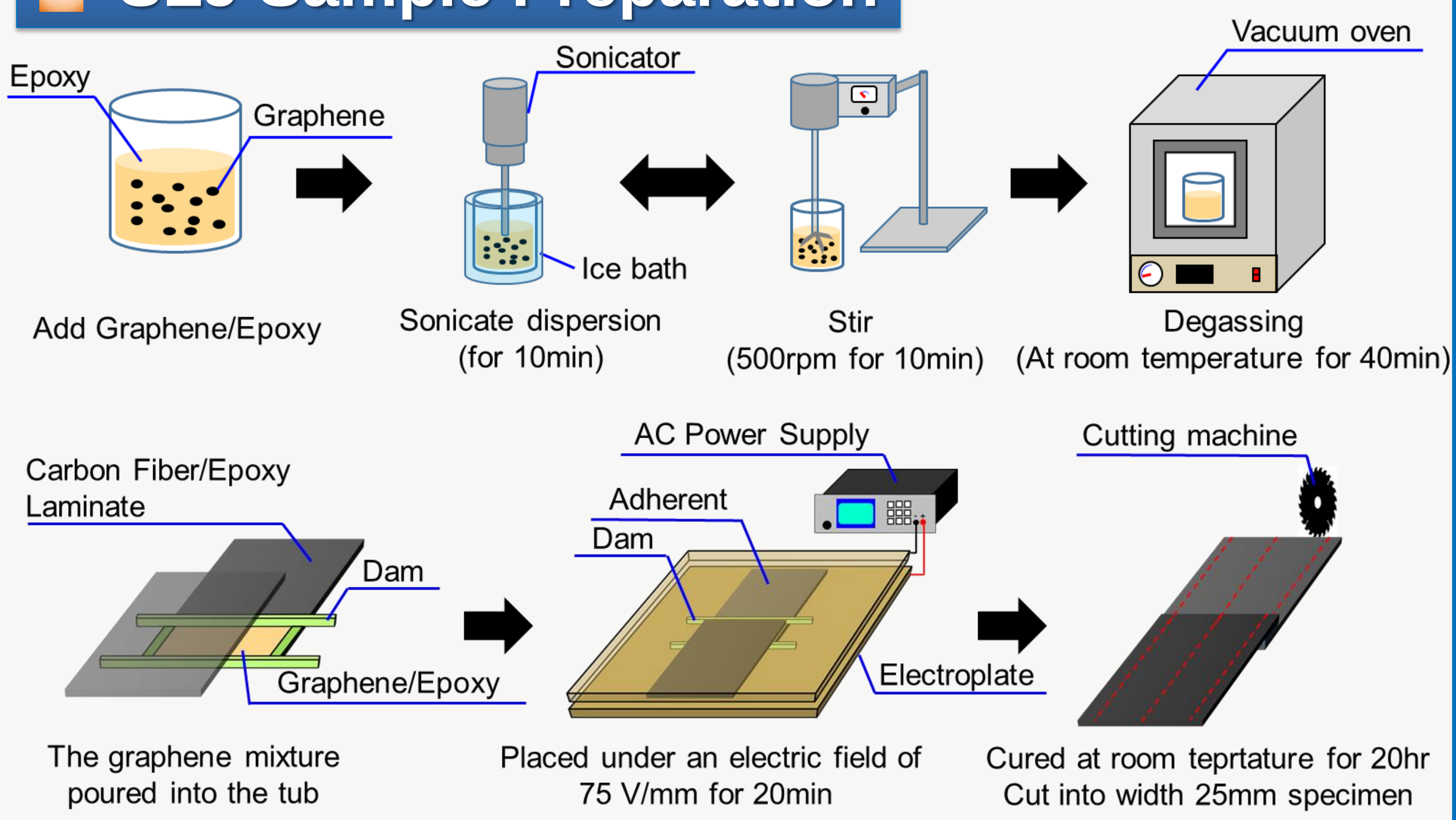
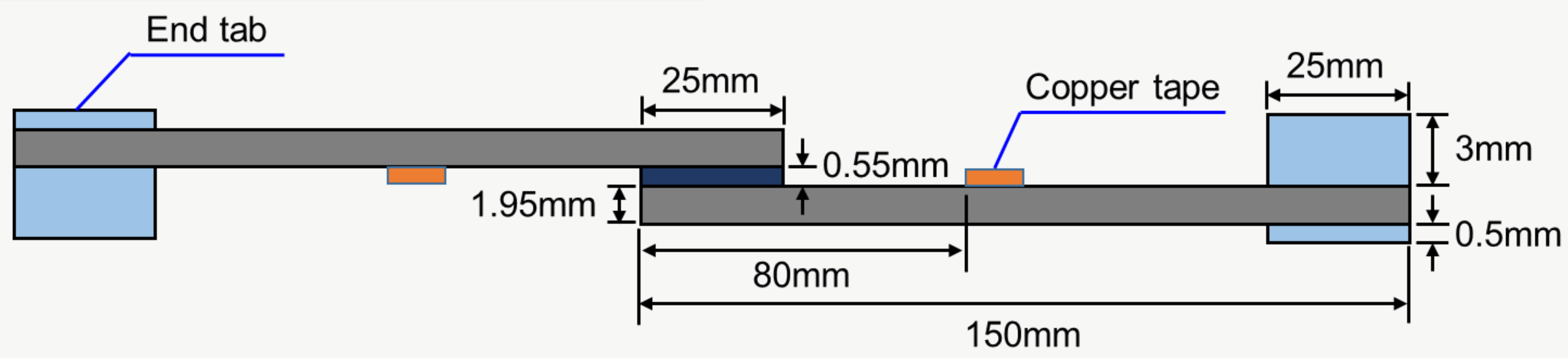
Abstract

Single lap joint (SLJ) with the advantage of being lightweight has been utilized in composite structures. However, the crack usually initiates and extends before the unexpected failure in SLJ. If the crack could be detected in advance, the catastrophic failure can be prohibited. In this study, reduced graphene oxide (RGO) and epoxy were used as the adhesive for composite adherent single lap joint (SLJ). An electric field was applied to align the graphene in the adhesive along the thickness direction of the joint. The resistance variation of the single lap joint was measured in the monoclinic and cyclic tensile tests. The resistance variation during crack initiation and extension were measured, and the correspondence between the resistance variation and crack extension length were established.

SLJ Sample Preparation

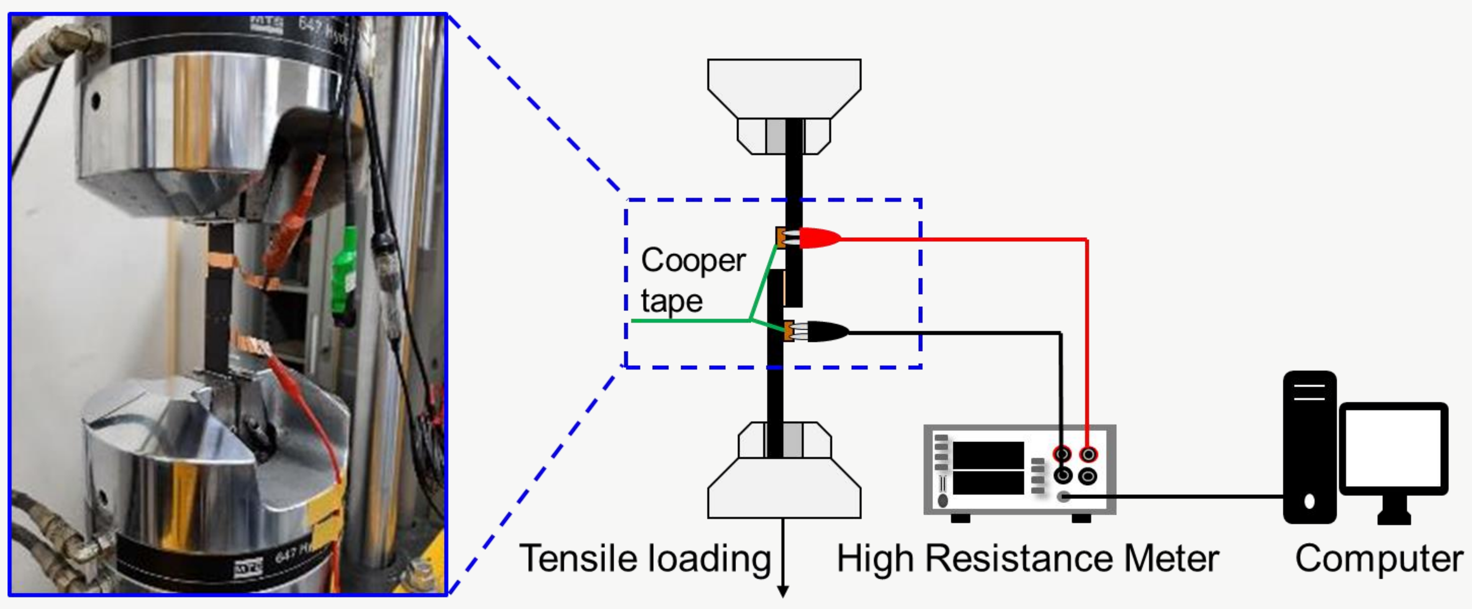


Joint geometry

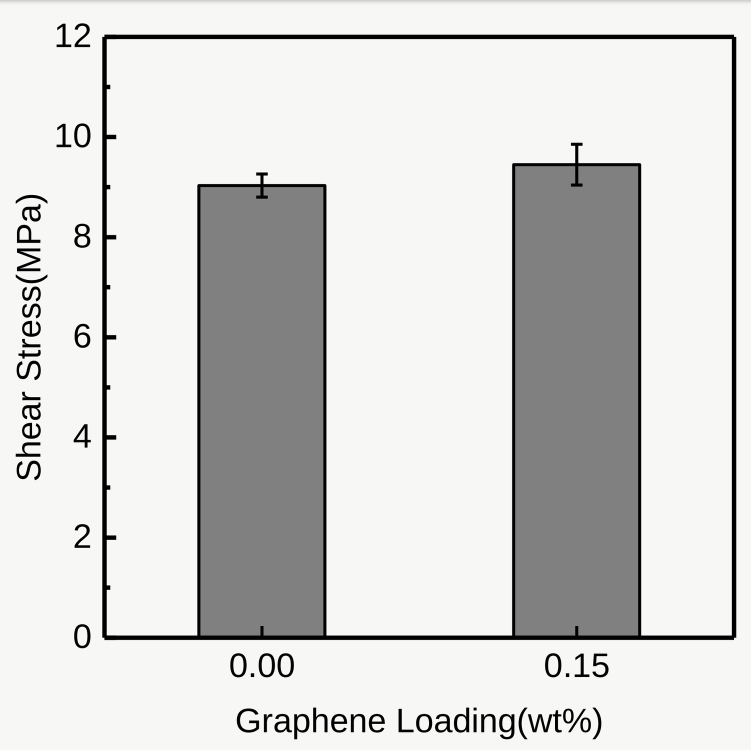


Monoclinic Tensile Test

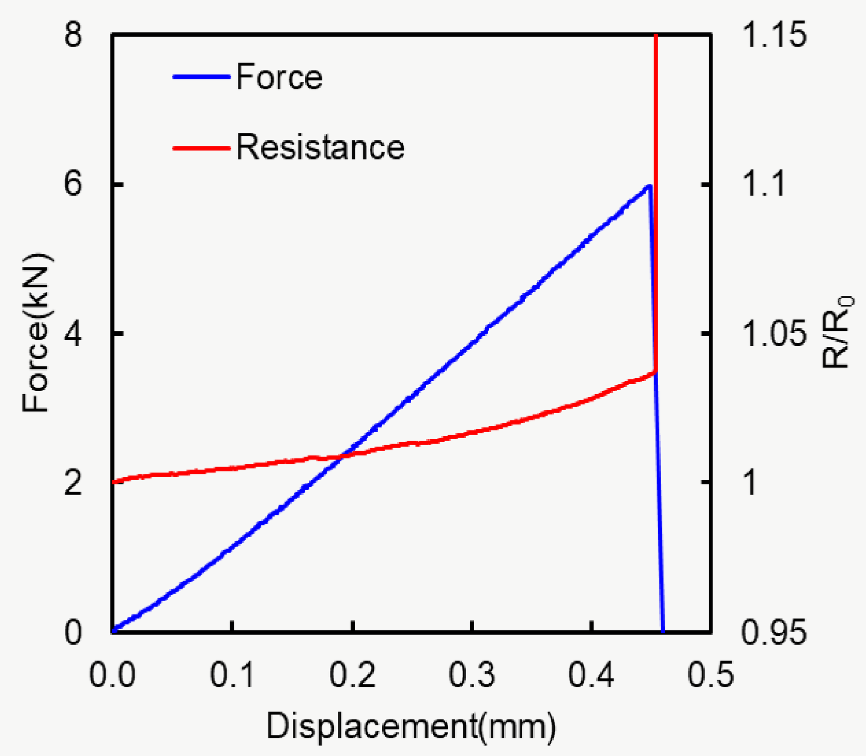
Experimental setup



Experimental Result



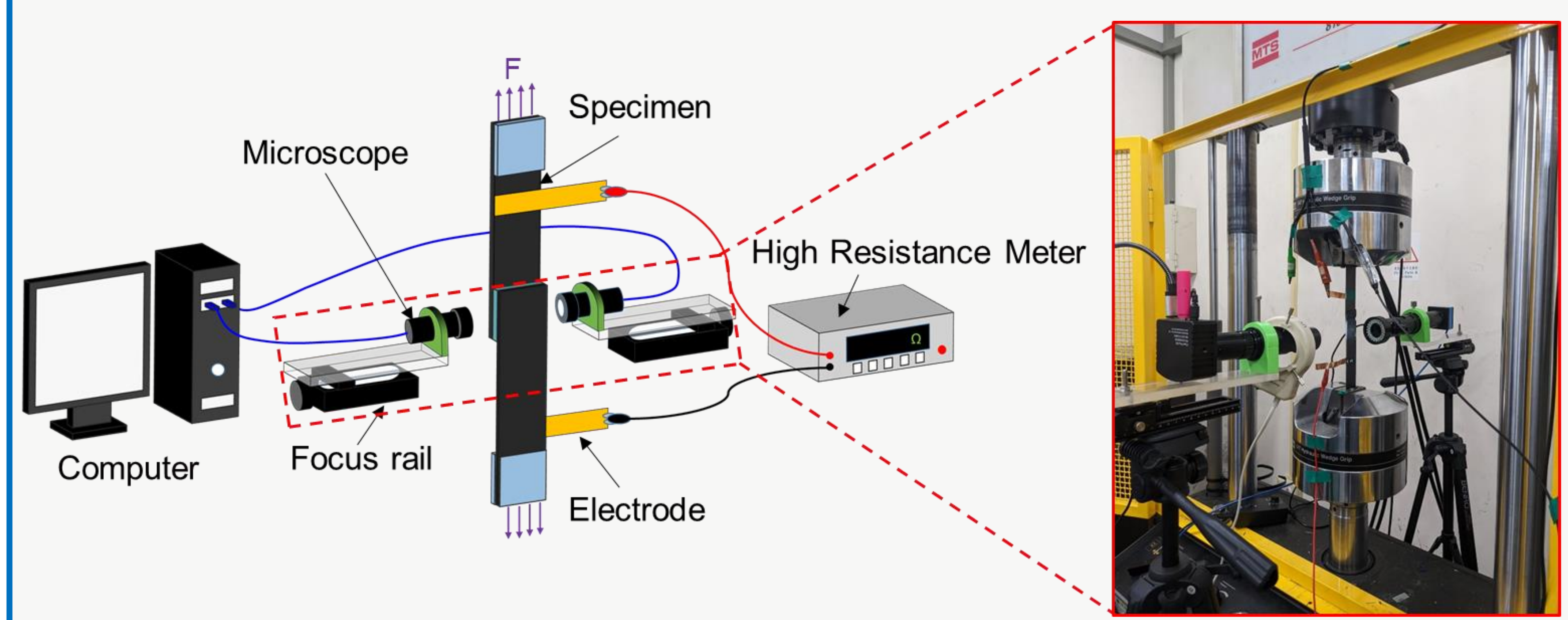
Effects of aligned graphene on adhesive bonded structure



Resistance variation of crack detection

Cyclic Test

Experimental setup



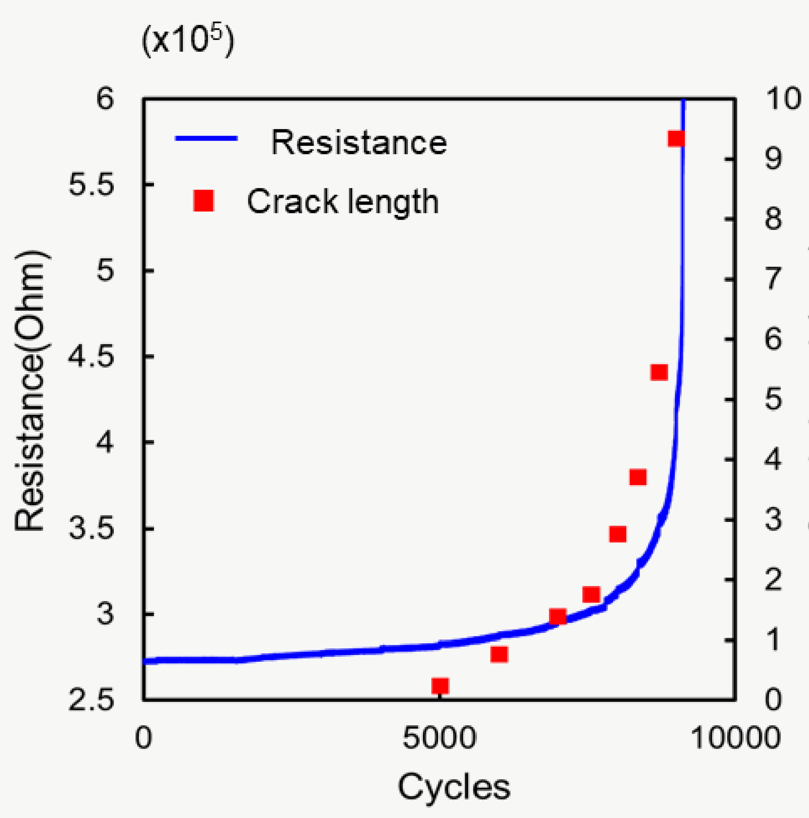
Resistance formulation

- $a=\frac{\alpha_1+\beta_1}{2}+\frac{\alpha_2+\beta_2}{2}$
- $\Delta R=R-R_0$
- $\frac{\Delta R}{R_0}=\frac{\frac{t_a a}{\kappa_a bL(L-a)}}{\frac{t_a}{\kappa_a bL}}=\frac{a}{L-a}$

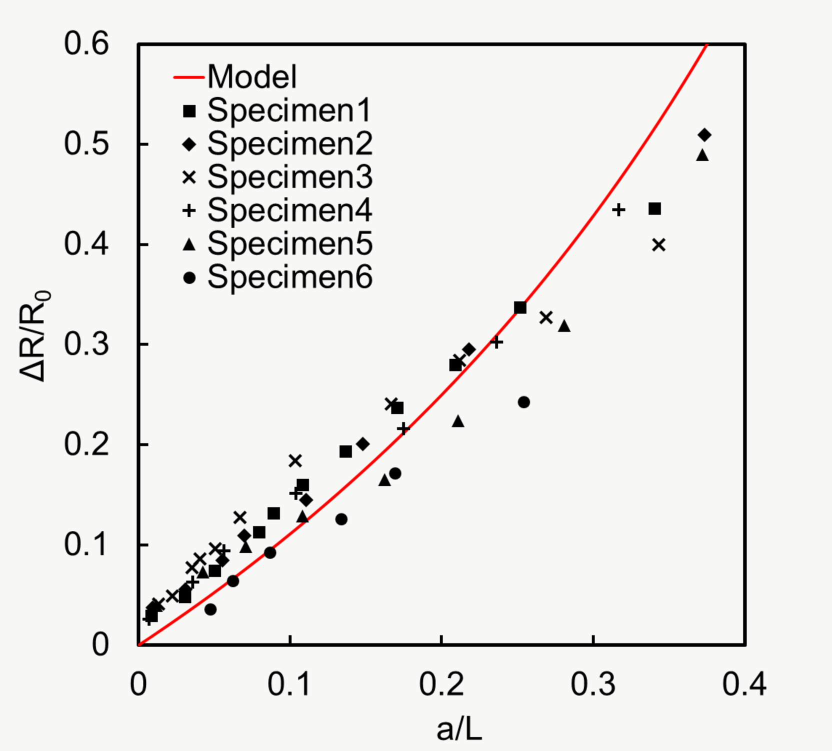
R : Measured electrical resistance
t_a : Adhesive bondind line thickness
L : Length of overlap
κ_a : Conductivity of aligned graphene

R_0 : Initial resistance
t_c : Thickness of adherent
L_c : Length of adherent
a : Crack length

Experimental Results



Resistance with Fatigue Cracks



Prediction of fatigue crack extension

Conclusions

The resistance technique was employed to examine the failure of the SLJ containing the aligned graphene embedded within the epoxy adhesive. For the monoclinic tensile tests, it is quite difficult to characterize the catastrophic failure in advance using the resistance technique since the resistance variation is not significant. On the other hand, in the cyclic tests, it was observed that the resistance variation is correlated with the increase of the crack length and prior to the failure, both crack length and resistance increase dramatically. Moreover, the increment of the resistance associated with the crack extended length have a good agreement with the model prediction.