Effect of an Atmospheric Pressure Plasma Treatment on the Mode I Fracture Toughness of a Co-Cured Composite Joint

1.Introduction

Convenient to co-cure the two materials using single processing process

- Pros:
  - Reduces cost
  - Reduce processing time
- Cons:
  - Epoxy resin contains moisture(free and bounded) → interfacial failure

- To eleminate the drawback:
  - Apply plasma treatment on the surface → Too much treatment is detrimental

- Most paper focuses plasma treatment on second bonding composite

- This paper investigates the effect on co-cured joints

2.Manufacture&Methods

Materials:

- 177 °C cure unidirectional carbon-fiber/epoxy prepreg (CYCOM 977-2/HTS)
- Dual 120/177 °C cure epoxy film adhesive (FM300-2M)

Each substrate consists 10plies of 977-2/HTS prepreg

Specimen:

Width:25mm Length:150mm Thickness:5.6mm Initial Crack Size:45mm

2.1 Fracture Test Methods

- Double cantilever beam test with British Standards 7991
- Constant crosshead displacement: 1mm/min
- Three repeats on each specimen

2.2 Scanning Electron Microscopy Method

2.3 Thermal Characterisation Methods

- Heated from 25°C to 350°C (10 °C /min)
- To determine glass transition temperature

2.4 Surface Energy Characterisation

- Sessile drop technique
- Surface energy is calculated with OWRK method.

2.5 Labline Plasma Treatment System

- Constant speed: 1.5 m/min
- Applied only on two prepreg surface that direct contact with film adhesive

2.6 Optical Emission Spectroscopy

- To analyze plasma content
- Always N2 peaks in spectrum(diffusion of air into plasma)
- He/O2 leads more interaction with prepreg → higher surface energy

2.6 X-Ray Photoelectron Spectroscopy

- To study chemical composition of treated surfaces
- Mean of 3 measurement on different spots

3 Result&Discussion

3.1 Surface Energy Analysis

Three gas mixtures:

- He
- He/N2
- He/O2

Power is fixed at 1200W

Maintained at 10L/min

Energy is measured after 2hrs

3.2 Mode I Fracture Toughness

- He/O2 treatment at 1600W

3.3 XPS Analysis

- Samples that treated with He/O2 at 1250W for 5 phase
- The presence of sulphur (thermoplastic toughening agent or agent in resin)
- Silicon concentration is in decrease(contamination)

3.4 Microscopy and Thermal Analysis

- Long treatment → reduced fracture tougness in co-cured joints
- ????

4 Conclusion

- He/O2 treatment is effective in increasing surface energy of prepreg.
- He and He/N2 is very inefficient in increasing the surface energy.
- Excessive treatments leads severe degradation in the performance under Mode I.
- Highly polar surface attracts moisture to the interface.
- Long plasma treatment causes pitting →reduction in fracture toughness