

Microstructure and Oxidation Behavior of CNT/PyC/SiC Coating on C/C Composite Material

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Abstract

CNT/PyC/SiC coating were prepared by direct growth of CNTs on C/C followed by deposition of PyC (pyrolytic carbon) and SiC. It is found that the coating consisted of two layers; the CNT/PyC/SiC layer and SiC layer. The oxidation resistance of C/C was improved by the coating, which had much fewer cracks and better thermal-shock resistance.

Introduction

Due to mismatch of coefficient of thermal expansion (CTE) between C/C composite and anti-oxidation ceramic coating, cracks and spalling in the coatings occurs. To minimize the effect of the mismatch, multilayer coatings have been developed [1]. But the bonding between C/C substrate and the coating and the bonding between layers are still weak due to the mismatch of their CTEs.

In this study, carbon nanotubes (CNT) and pyrolytic carbon (PyC) were used to reinforce SiC coating and suppress the thermal stress in the coating to minimize cracking and improve the bonding between C/C and the coating, thus improve the oxidation resistance of C/C composites.

Experimental

Then CNT were grown on C/C composites at 700°C using C₂H₂ as carbon source for 20min. The deposition of PyC was performed using methane as carbon source at 1150°C, under a pressure of 4 kPa for 5-45 min. Subsequently, the source was switched to CH₃SiCl₃ for deposition of SiC for 60min. SiC coating, CNT/SiC coating and CNT/PyC/SiC coating (X denoted deposition time of PyC) were prepared. The microstructure of the coating was observed using SEM and TEM. Isothermal oxidation tests were carried out at 1200°C for 2 hours in air of 30ml/min using TG. Thermal cyclic oxidation tests were carried out between 1200°C and room temperature.

Results and Discussions

From SEM and TEM observation, CNTs with diameter of 30-70 nm were formed uniformly on C/C surface. After deposition of SiC, CNT/SiC coating were obtained. The surface morphology of SiC coating and CNT/SiC coating were similar, however, they showed different microstructure of cross-section. SiC coating had a distinct boundary with C/C substrate, while no distinct boundary between CNT/SiC coating and C/C was observed. When PyC was deposited on CNT, the diameter of CNTs increased to 140-300nm, depending upon the deposition time. After deposition of SiC, CNT/PyC/SiC coatings were obtained. Fig.1 shows cross section of CNT/PyC10/SiC coating. Coatings consisted of two layers with different morphology: the inner CNT/PyC/SiC layer and the outer SiC layer. The

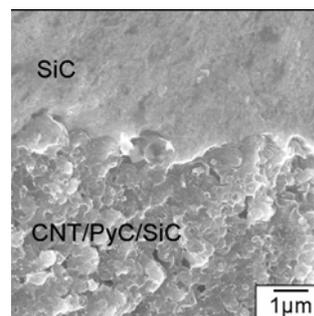


Fig. 1. SEM image of cross section of CNT/PyC10/SiC

boundary between C/C and CNT/PyC/SiC layer was not distinct, suggesting that the bonding between CNT/PyC/SiC layer and C/C composites

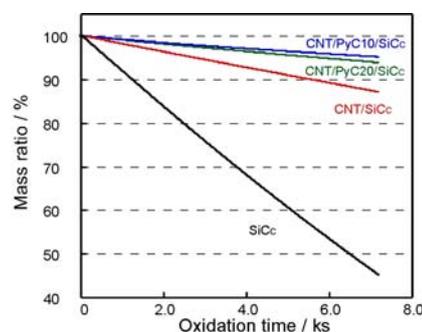


Fig. 2. Isothermal oxidation test of C/Cs with CNT/PyC/SiC coating.

should be stronger than a direct SiC coating on C/C composites. Since SiC was deposited continuously, CNT/PyC/SiC layer also had a strong bounding to SiC layer.

Fig.2 shows result of isothermal oxidation test at 1200°C for 2 hours. Oxidation resistance of coated samples were improved by using CNT/SiC coating, and further improved by PyC deposition from 5 to 20 min. If PyC deposition time is over 25 min, oxidation resistance was inferior to CNT/SiC coating. In addition, result of thermal cyclic oxidation test indicated CNT/PyC10/SiC and CNT/PyC20/SiC coating had much better thermal shock resistance than SiC coating and CNT/SiC coating.

Conclusions

The CNT/PyC/SiC and SiC double-layer coating had no distinct boundary with the C/C surface, thus had a strong bonding. The CNT/PyC/SiC coatings with PyC deposited for 10-20 min showed higher oxidation protection.

References

1. Y.-C. Zhu, S. Ohtani, Y. Sato, N. Iwamoto, *Carbon*. **38**, 501-507 (2000).