Anti-oxidation property of CNT/PyC/SiC coating for Carbon/Carbon composites

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Introduction

Ceramic coating, such as SiC, is required to prevent the oxidation of the C/C, since C/C composites are prone to oxidize above 723K in air. However, due to mismatch of coefficient of thermal expansion (CTE) between C/C composites and ceramic coating, cracks formed in the ceramic coating on cooling from high temperature.

In order to suppress the cracking in coating, CNT/PyC/SiC coatings were produced by chemical vapor deposition of pyrolytic carbon (PyC) and SiC into CNT layer, which was dip-coated on C/C surface. CNT and PyC were used to suppress cracks and reinforce the bonding between C/C composites and SiC coating. In our previous study, CNT layer was prepared by direct growth of CNTs on C/C substrate. However, this process is too difficult to control the quality of CNTs and thickness of CNT layer. Therefore, in this study, CNT layer was prepared using dip-coating. The effect of CNT layers on the anti-oxidation property of CNT/SiC and CNT/PyC/SiC coating was investigated.

Experimental

CNTs were treated with mixed solution of sulfuric acid and nitric acid at 110ºC for 2 hours. Then, CNTs layer was prepared by dip-coating of C/C in CNT dispersion. The deposition of PyC was performed using propane as carbon source at 1150°C, under a pressure of 5 kPa for 1, 3, 5 min. Subsequently, the source was switched to CH_3SiCl_3 for deposition of SiC, under a pressure of 4 kPa for 60min. SiC coating, CNT/SiC coating and CNT/PyCX/SiC coating (X denoted deposition time of PyC) were prepared. The microstructure of the coating was observed using SEM. Isothermal oxidation tests were carried out at 1200°C for 2 hours in air of 30ml/min using TG.

Results and Discussion

CNTs used in this experiment were MWNTs with an average diameter of 20 nm. Fig.1 shows SEM images of cross-section of CNT layer, CNT/PyC coating, CNT/PyC/SiC coating. From Fig.1 a), it can be seen that thickness of the CNT layer varied from 5 to 20 μm with an average of 10 μm. From Fig.1 b), PyC deposited into small space among CNTs, but still left large pores among CNT aggregates. From Fig.1 c), It can be seen that, CNT/PyC3/SiC coating consisted of two layers with the inner CNT/PyC/SiC layer and the outer SiC layer with coating thickness ranging from 20-30 μm. CNT pullout could be observed from the fracture surface of the coating, suggesting reinforcement effect of CNT. However, the coating was not very dense due to formation of whisker-like SiC.

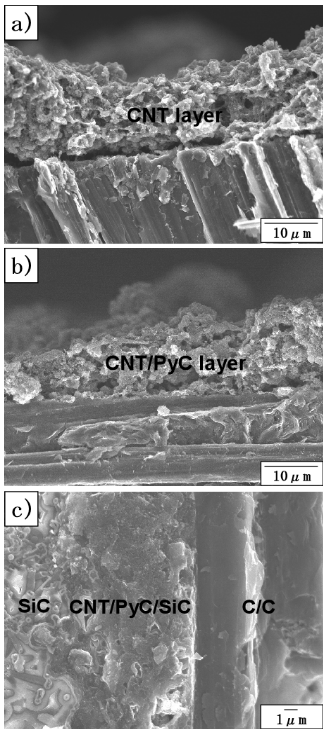

Fig.1 SEM image of cross-section of samples. a) CNT b) CNT/PyC c) CNT/PyC3/SiC

Fig.2 shows the results of isothermal oxidation test at 1200°C for 2 hours. Compared with the SiC coated C/C composites, the CNT/SiC coated samples exhibited an obvious improvement of oxidation resistance. While compared with the CNT/SiC coated samples, the CNT/PyC/SiC coated samples showed a better anti-oxidation property. Among them, The CNT/PyC3/SiC coatings with PyC deposited for 3 min showed the best anti-oxidation property. It is believed that the better anti-oxidation property of CNT/PyC/SiC coated C/C samples was primarily due to less the cracking in coating by CNT. However, complete anti-oxidation is not achieved yet. Further researches are carried out to improve the coating.

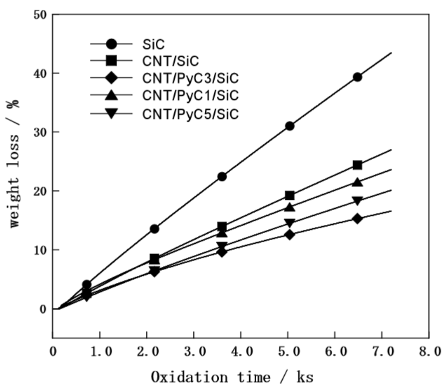

Fig.2 Isothermal oxidation test of C/C composites with CNT/PyC/SiC coating.

Conclusions

CNTs have intense effect on the oxidation property of the SiC coating on the C/C composites. The CNT/PyC/SiC coatings with PyC deposited for 3 min showed best anti-oxidation property.

References

1. Yu-Lei Zhang, He-Jun Li et al. Surface & Coatings Technology 201 (2006) 3491-3495