INTERFACIAL REACTIONS BETWEEN COATED NICALON FIBER AND TITANIUM

D.M. YANG, C.X. HUANG, D.T. HUANG AND X. ZHAO
Dept. of Materials Science, Changsha Institute of Technology, Hunan, China

ABSTRACT

Kinetics of interfacial reactions between coated and uncoated Nicalon fibers and titanium is investigated. TaC and Al coating fibers prepared by CVD and PVD methods respectively are used. The specimens are made by powder metallurgy and treated at 900-1000°C in vacuum. The thickness of the reaction zone which is measured on image analysis system yields expected parabolic growth relationship. It is found that the reaction rate constant for TaC coating fiber with titanium is less than the half of that for uncoated fiber, but the result for Al coating fiber is a little less than that for uncoated fiber. Electron Microprobe, X-ray diffraction and metallography analyses show that there are three layers existed in the reaction zone between TaC coating Nicalon fibers and titanium which is composed of Ti₆Si₃, Ta₆Si₃, (Ti, Ta)C and a diffusion layer of tantalum.

INTRODUCTION

The reaction between SiC fiber and titanium at elevated temperature is the main obstructor for developing SiC fiber reinforced titanium composites. So that, it is an important basic work to investigate the interfacial reaction of SiC fiber with titanium and the influence of coatings on reaction kinetics. There had been several references about the reaction kinetics of Borsic, SCS-6 fibers with titanium and its alloys [1, 2, 3]. Reference [4], [5] had respectively reported the effect of aluminium and TaC coating on compatibility of SiC with titanium. Nicalon SiC fiber is produced from Polycarbosilane by melt spinning, curing and heat treatment. Its surface composition and structure are different from those of SiC fibers produced by CVD process. The main purpose of this paper is to study the reaction kinetics of Nicalon fiber and its aluminium or TaC coatings with titanium and the structure characteristics of reaction zone.
MATERIALS AND PROCEDURE

Two kinds of SiC samples were used, one is Nicalon fiber produced by Nippon carbon Co. Ltd., another is PCS-SiC fiber with the diam of 100 μm produced by ourself. The metal matrix is pure titanium powder. Before being used, the powder was treated in vacuum at 600°C for 40 min in order to remove hydrogen. Aluminium and TaC coating were obtained by PVD and CVD process and their thicknesses are 0.5 μm and 0.75 μm respectively. The chopped fibers and titanium powders were mixed, cold pressed into small cylinder, and then were sintered in vacuum (2-5×10^{-5}tor ) at 900-1100°C for various time. The microstructure of interfacial reaction zone was investigated by metallography, and the thickness of reaction layer was measured on Automatic Interactive Analyser IBAS2. The measuring procedure is shown in Fig 1. By a special measuring program, the eight intercepts can be obtained (Fig.1 a,b c) and their lengths $L_i$ can be measured. As shown in Fig.1 d, the intercept length $L_i$ on transverse section can be calculated as follow:

$$L_i' = L_i [E^2 + (1-E^2) \sin^2 \alpha_i]^{1/2}$$  \hfill (1)

Where, $E$ is an elliptic shape factor defined by the ratio of minor axis to major axis, $\alpha$ is the angle between test line and major axis. The average value of the eight $L_i'$ is regarded as the reaction layer thickness of this fiber and then ten fibers which were randomly chosen were measured. The chemical composition and structure of reaction zone were identified by electron microprobe and X-ray analysis. For increasing the sensitivity, the reaction products were enriched by electrolytic extraction and Debye method was used in X-ray analysis. Electrolyte was composed of 1000 ml methyl alcohol, 50g citric acid and 30 ml perchloric acid. The current density was 50mA/cm . The electrolysis time was 8 hrs.

RESULTS

Metallographic Analysis of Interfacial Reaction Layer

The reaction layer between SiC and Ti can be easily viewed in metallographic specimens mentioned above. Photo 1 is the metallograph of uncoated SiC/Ti sample, the reaction layer thickness increases as temperature and time increase. The interfacial reaction product of SiC(TaC)/Ti exhibits a multilayer structure. The specimen surface etched in 30 ml HNO₃, 30 ml lactic acid and 1 ml HF for 15