Wetting and interfacial reactivity in the Ta-X (X=Co, Ni)/SiC system

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Introduction

SiC based Ceramic Matrix Composites (CMCs) are materials of interest for the aerospace industry because of their appealing combinations of properties including high thermal, mechanical and chemical stability and low weight. Reliable and effective joining technologies are required to assemble these materials in complex shapes or to integrate them into existing metallic parts forming hybrid structures. Liquid based processes (e.g. brazing, transient liquid phase bonding) are often preferable to avoid surface preparation, high pressures or when the adjoining surfaces are not flat.

In this context, a new understanding of wetting and interfacial reactivity of liquid brazing alloys in contact with the materials to be joined, is essential.

Background

Using pure Ni or Co for brazing SiC is unfavourable because of the strong reactivity towards the ceramic substrate with dissolution and precipitation of graphite and silicides [1,2].

Steps of liquid-solid interactions:

1. Liquid M in contact with SiC
2. Dissolution of SiC until conc. A
3. Precipitation of C
4. Dissolution to B through the red line

Experiment and results

Tests were conducted by the sessile drop technique. The experimental apparatus consists of a specially designed furnace made of two concentric, horizontal alumina tubes connected to a high vacuum system. Angles and dimensions were measured with the AstraView image analysis software.

Ni-Ta, Co-Ta alloys

- Dissolution of SiC substrate and formation of TaC, graphite and Co silicides

Evaluation of wetting and kinetics

$
\theta_i = 42^\circ
$

For low Ta content the interfacial behaviour is dissipative, similarly to the pure metals ones and the respective ternary phase diagrams

Ni-Ta alloys on SiC

- High Ta content $X_{\text{Ta}} = 0.38$

Evaluation of wetting and kinetics

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\theta_i < 10^\circ
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For high Ta content the dissolution is almost suppressed

Thermodynamic approach

A thorough study of the binary and ternary diagrams including the elements of the ceramic substrate (C, Si) and of the alloys (Co, Ni, Ta) has started.

- Thermodynamic database including C, Co, Ni, Si, Ta.
- Definition of the new ternary phases (e.g. CoSiTa).
- Joining improvement: definition of the best alloys compositions and process parameters
- Prediction and evaluation of the higher order phase equilibria.

Conclusions

- A good wetting was obtained for Ta-X (X=Ni, Co) alloys in contact with CVD-SiC substrates.
- The interfacial behaviour was found to be the result of the interplay between dissolution of the ceramic phase and formation of interfacial TaC.
- At low contents of Ta, dissolution of the SiC substrate was found similar to the well known systems Ni-Si-C and Co-Si-C with formation of silicides and graphite.
- Using alloys with high content of Ta led to the suppression of dissolution and formation of a layer of TaC at the metal/ceramic interface.

References
