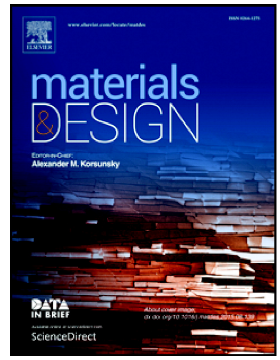

Formation mechanisms of Ti2AlC MAX phase on SiC-4H using magnetron sputtering and post-annealing

J. Nicolaï, C. Furgeaud, B.W. Fonrose, C. Bail, M.F. Beaufort

PII: S0264-1275(18)30137-0
DOI: doi:10.1016/j.matdes.2018.02.046
Reference: JMADE 3713

To appear in: *Materials & Design*

Received date: 24 December 2017
Revised date: 12 February 2018
Accepted date: 15 February 2018

Formation mechanisms of Ti_2AlC MAX phase on SiC-4H using magnetron sputtering and post-annealing

J. Nicolaï,[1)] C. Furgeaud,[1)] B. W. Fonrose,[2)] C. Bail,[1)] and M.F. Beaufort[1)]

[1]*Institut Pprime, UPR 3346, Université de Poitiers, SP2MI-Boulevard 3, Téléport 2-BP 30179, 86962 Futuroscope Chasseneuil Cedex, France*

[2]*CEMES-CNRS-UPR 8011, Université de Toulouse, 31055 Toulouse, France*

Abstract

In the present work we focus on the mechanisms involved in Ti_2AlC MAX phase thin-film formation. The $TiAl_2$ thin-film was deposited by magnetron sputtering on a SiC-4H [0001] substrate. Samples were annealed at various temperatures (700-800°C) for various times and analysed by XRD and TEM. The epitaxial Ti_2AlC phase was formed as follows: $[0001]_{MAX}$ // $[0001]_{SiC}$ and $(11\text{-}20)_{MAX}$//$(11\text{-}20)_{SiC}$ which is in a good agreement with thermodynamic considerations. The presence of TiC structures at the interface indicates that the formation of this structure is necessary to obtain Ti_2AlC. Moreover, the formation of a liquid AlSi alloy was highlighted due to the interdiffusion of Al and Si respectively from $TiAl_2$ and SiC during TiC formation. Finally, we assume that, during the cooling, the AlSi alloy separates and Al diffuses to the surface of the $TiAl_2$ layer leading to the formation of an Al-rich layer. The remaining Si reacts with Ti from $TiAl_2$ to form a Ti_5Si_3 layer following this epitaxial relation: $[0001]_{Ti2AlC}$ // $[0001]_{Ti5Si3}$ and $(11\text{-}20)_{Ti2AlC}$//$(3\text{-}210)_{Ti5Si3}$. These mechanisms lead to the stacking of four different layers. Between 700 and 800 °C, the nature of the formation mechanism is not time-dependent. However, the kinetics of the reactions are both temperature and time dependent.

Keywords: MAX phase, thin film, epitaxy, TEM, Magnetron Sputtering

Introduction

$M_{n+1}AX_n$ phases (n=1-3) are in a large class of nanolaminated materials. M is an early transition metal element, A is an A-group element and X is either C or N [1-4]. For n=1, 2, 3 the MAX phases are called 211, 312 and 413 respectively due to the periodic arrangement of the structure: MX octahedrons with layers of the A element in a hexagonal structure. This particular arrangement gives the MAX phases a unique combination of metal and ceramic properties, opening the way to a large field of applications [5-7]. The Ti_3SiC_2 and Ti_2AlC MAX phases have been extensively studied due to these excellent properties which include irradiation resistance [8-9]. Several different techniques have been used to synthesize bulk MAX phases. Of these techniques, the most common is hot isostatic pressing (HIP) [10]; however, various techniques have been developed for the growth of MAX phase thin films using magnetron sputtering technology, either from elemental targets or from compound targets on various substrates [11-14]. As shown on our recent papers, the co-deposition of Ti and Al on SiC substrates leads, under specific annealing conditions [15-16], to the formation of Ti_3SiC_2 films. The use of Al is known to be helpful to the