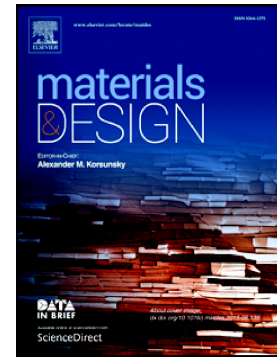


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Formation mechanisms of Ti₂AlC MAX phase on SiC-4H using magnetron sputtering and post-annealing

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Abstract

In the present work we focus on the mechanisms involved in Ti₂AlC MAX phase thin-film formation. The TiAl₂ 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 Ti₂AlC phase was formed as follows: [0001]_{MAX} // [0001]_{SiC} and (11-20)_{MAX} // (11-20)_{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 Ti₂AlC. Moreover, the formation of a liquid AlSi alloy was highlighted due to the interdiffusion of Al and Si respectively from TiAl₂ and SiC during TiC formation. Finally, we assume that, during the cooling, the AlSi alloy separates and Al diffuses to the surface of the TiAl₂ layer leading to the formation of an Al-rich layer. The remaining Si reacts with Ti from TiAl₂ to form a Ti₅Si₃ layer following this epitaxial relation: [0001]_{Ti2AlC} // [0001]_{Ti5Si3} and (11-20)_{Ti2AlC} // (3-210)_{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 Ti₃SiC₂ and Ti₂AlC 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 Ti₃SiC₂ films. The use of Al is known to be helpful to the

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