

Ti₂SnC and Ti₂InC Nanolaminates by Low Energy Ion Facility (LEIF) and Their Resistance Towards Ar⁺ Ion Bombardment

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MAX phases are known as nanolaminated ternary carbides and nitrides of chemical formula M_{n+1}A_x (n=1-3), where M is an early transition metal, A is an A-group element, X is carbon or nitrogen [1]. Their damage tolerance and high resistance to oxidation and corrosion predict that these compounds should be of interest for applications in harsh environmental conditions. Ti₃SiC₂ was first mentioned as a possible constituent for the cladding in fuel rods [2]. It was confirmed that Ti₃SiC₂ is insensitive to electronic losses also and the behavior of MAX phases under ion irradiation has found a growing interest in the last five years. It was documented that the key parameter determined the properties of MAX phases is A element since replacing Si by Al in the Ti₃AC₂ system highly improves the irradiation induced amorphization tolerance of the nanolaminates [3]. Nevertheless, different behaviors under ion irradiation observed for MAX phases, and the origins of these differences remain unclear.

Here we describe the advantages offered by an unconventional method utilizing sputtering of individual elements by LEIF to prepare Ti₂SnC and Ti₂InC nanolaminates. The LEIF facility was utilized without a separation magnet, which means that the M₂AX phase targets were bombarded with a mixture of Ar⁺ and Ar²⁺ ions. The Ar⁺ ions were accelerated to the energy 25 kV, the beam current was kept on a high level of 400 μA. The target holder was designed in a specific way in order to (i) keep the M₂AX phase elements separated and (ii) rotate the holder with a variable rotation speed based on a sputtering yield of each M₂AX phase element. After sputter deposition, the samples were subsequently annealed in vacuum at 120 °C for 24 hrs in order to induce interphase chemical interaction and complete formation of the stoichiometric corrected M₂AX compounds. The as obtained Ti₂SnC and Ti₂InC nanolaminates were further investigated for structural and controlled modification by energy ion beams. In order to analyze the radiation stability in the terms of damage profile, the Ar⁺ ions irradiation was performed. As-prepared samples were irradiated by 35 keV Ar⁺ ions in order to analyze the radiation induced structural deformation and radiation stability in the terms of damage profile. The fluence of the ions was picked to 10¹⁴ ions cm⁻². The aim was to compare our results with recently synthesized Ti₂InC and Ti₂SnC thin films, which are good templates to investigate the influence of the chemistry on the A site in these Ti-based compounds, because of the large mass difference between In and Sn elements.

Figure 1 reveals nanocrystalline 2D Ti₂SnC phase with hexagonal structure (SG = P6₃/mmc) and isotropic contribution of grains with size of about 10 nm. Ar ion irradiation led to accelerate shrinking process as a function of point defects within the grains and deformation in grain boundaries. Figure 2 shows uniform nanocrystalline film of Ti₂InC with wormlike microstructure and regular hexagonal anisotropic grains before Ar irradiation. After Ar⁺ irradiation we observed mixture of Ti₂InC and cubic Ti₃InC and high degree of polygonization. Our results confirmed extremely stable Ti₂SnC

