Seminar

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Institute for Plasma Research

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Title: Feasibility study of synthesis of MAX phase materials for fusion and non-fusion applications

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Date: 08th May 2026 (Friday)

Time: 10:30 AM

Venue: Seminar Hall, IPR

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Abstract

MAX phases are ternary layered ceramics with the general formula Mn+1AXn (where M is a transition metal, A is an A-group element, and X is carbon or nitrogen). They offer a useful mix of metallic and ceramic properties [1,2]. These materials are highly suitable for nuclear applications because of their mechanical, thermal, and chemical stability [3, 4]. A combined property of high temperature performance with machinability like metals make them lucrative. For example, Cr2AlC shows excellent oxidation resistance by forming a dense, self-healing Al2O3 layer at temperatures up to 1400°C, which protects it in oxidizing environments [5].

As a first step, this study involved synthesis of high purity Cr2AlC powder. This was achieved by mixing chromium, aluminum, and carbon powders, followed by a two-step pressureless sintering process in an argon atmosphere. Characterization using XRD and Raman spectroscopy confirmed the formation of a pure Cr2AlC phase with no impurities. SEM imaging showed the expected layered structure, while EDX confirmed the correct atomic percentages of Cr, Al, and C. XPS analysis verified the Cr-C bonds characteristic of the MAX phase. Thermal analysis via TG-DSC indicated a weight increase of 4% indicating possibility of protective oxide (Al2O3) generation as corroborated with SEM. However, high-temperature B-B mode XRD at 1000°C in 10^{-2} mbar pressure showed no peaks of Al2O3 or CrO during heating indicating that the protective film so formed may be very thin (<0.5 μm).

The second step of this study was to evaluate the feasibility of using this material as a barrier coating for blanket applications. To test this feasibility, the synthesized Cr2AlC powder was coated onto SS 316LN steel using thermal plasma spray process on 150 mm x 150 mm sample size. The coated samples have been subjected to basic characterization studies including XRD, SEM and EDS. Additionally, the Cr2AlC powder has been subjected to field assisted sintering in Gleeble Machine and the resultant compacted sample has been found to have a density of 5.14 g/cm^3. The XRD indicates no phase change during the sintering procedure. The evaluation and detailed characterization is underway.

References:

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3. Lambrinou1, K., et al. "MAX phase materials for nuclear applications." Developments in Strategic Ceramic Materials II: Ceramic Engineering and Science Proceedings Volume 37, Issue 7 37 (2017): 223-233.

4. Rigby-Bell, Maxwell TP. Developing MAX phases for nuclear fusion. The University of Manchester (United Kingdom), 2022.

5. Z. Lin et al., High-Temperature Oxidation and Hot Corrosion of Cr2AlC, Acta Mater., 2007, 55(18), p 6182–6191.