MAX phases: hype or revolution?

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MAX phases have attracted considerable attention in the last years due to their unique combination of properties, bridging the desired gap between ceramics and metals. The combination in a single material of lightweight, high elastic modulus, good oxidation and corrosion resistance, radiation tolerance, and self-crack healing with high fracture toughness and damage tolerance, thermal shock resistance and ease machinability has brought a massive interest and a potential revolution in terms of materials science. However, despite the high potential of some compositions such as Ti_2AlC and Cr_2AlC, their transfer to applications has been limited. This might indicate a hype of this family of materials with more than 150 different compositions. This presentation will provide the scientific knowledge, state of the art, potential applications, and challenges to evaluate the real potential of these materials, including the three main limiting factors: i) complexity of this large family of materials, ii) unavailability of highly pure commercial powders, and iii) extensive time to license products in strategic fields such as nuclear or aviation.

In this presentation, drawbacks and potential solutions of these three limiting factors are discussed and correlated to the main properties of MAX phases and their synthesis routes. Emphasis is given to processing routes for developing different structures such as dense bulk samples, ceramic matrix composites, foams with controlled porosity, coatings, and near-net shaping. Furthermore, well-known and novel potential applications such as structural materials for high temperature applications, protective coatings and bond-coats for gas turbines, accident tolerant fuel cladding in nuclear power plants, solar receivers in concentrated solar power systems, electrical contacts, and catalysis are described as well as future challenges to facilitate the transfer to the market.