Synthesis and characterization of novel MAX phases

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MAX phases adopt crystal structures displayed in Figure 1 and show highly unusual mechanical, thermal, and electronic properties. While they conduct heat and electricity like metals, they are elastically stiff, strong, brittle, and heat-tolerant like ceramics. Some of the MAX phases kink and delaminate during deformation, many are resistant to chemical attack, readily machinable, and thermal shock, damage tolerant, and sometimes fatigue, creep, and oxidation resistant. Therefore, these systems attract great interest from point of view of industrial applications, including nuclear industries and renewable energy [2-4].

In this project, you will synthesize novel MAX phases using methods available in the Synthetic Solid State Physics lab at UCLan. You will use Bruker D2 Phaser powder X-ray diffractometer and JCM-6000Plus scanning electron microscope to study crystal structures, microstructures, and chemical compositions of crystals and/or polycrystalline specimens. If time allows, you will be given an opportunity to investigate basic physical properties of the synthesized MAX phases at temperatures down to 4 K using a dry cryostat.



Figure 1: Crystal structures of MAX phases, i.e. layered hexagonal compounds with the chemical formula Mn+1AXn, where 'M' corresponds to an early transition metal, 'A' corresponds to an A-group element, 'X' corresponds to either carbon or nitrogen, and n=1, 2 or 3 (taken from [1]).

[1] Grey, V. (2014) Ti₃SiC₂and Ti₃AlC₂ Single Crystal Elastic Shear Modulus: Investigation via Inelastic Neutron Scattering and Computer Simulation. Newcastle University.

[2] Barsoum, M.W. (2000) 'The $M_{n+1}AX_n$ phase: a new class of solids; thermodynamically stable nanolaminates', Progress in solid state chemistry **28**, 201.

[2] Sun, Z.M. (2011) 'Progress in research and development on MAX phases: a family of layered ternary compounds', International Materials Reviews **56**, 143.

[3] Radovic, M. and Barsoum, M.W. (2013) 'MAX phases: Bridging the gap between metals and ceramics', American Ceramic Society Bulletin **92**, 20.

[4] Gonzalez-Julian, J. (2020) 'Processing of MAX phases: From synthesis to applications', Journal of the American Ceramic Society **104**, 659.