In Situ (S)TEM of Study of Thermally Induced Phase Transitions for Titanium MAX and MXene Phases

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Two-dimensional (2D) nanomaterials with differing compositions and morphologies have long been of interest to a wide range of scientific communities. MXenes, a material of this class, first synthesised in 2011 display a range of properties associated with 2D materials with wide applications in energy storage materials research [1, 2]. Since their conception, emphasis has been placed on understanding their behaviours in various environments to aid knowledge of their degradation leading to structural changes which is linked to their synthetic process. One such environment for example is under extreme temperatures. It has been documented that $Ti_3C_2T_x$ undergoes phase transitions at high temperatures leading to formation of carbides and oxides, however further detailed investigations at a nanoscale are needed to fully understand transition processes and formation of secondary phases which alter the original MXene initial thought to be stable [3, 4]. Herein, an investigation is presented into the phase transition of $Ti_3C_2T_x$ by *in situ* electron microscopy at elevated temperatures >600 °C coupled with high spatial and temporal resolution transmission electron microscopy (TEM), electron diffraction and energy dispersive x-ray spectroscopy. It is envisaged that our *in situ* TEM experiments will lead to a higher level of understanding and control over the secondary phase formation and will further support development of highly stable MXene - extending their application ranges, namely in the fields of energy storage materials and photocatalysis.

References

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Figures

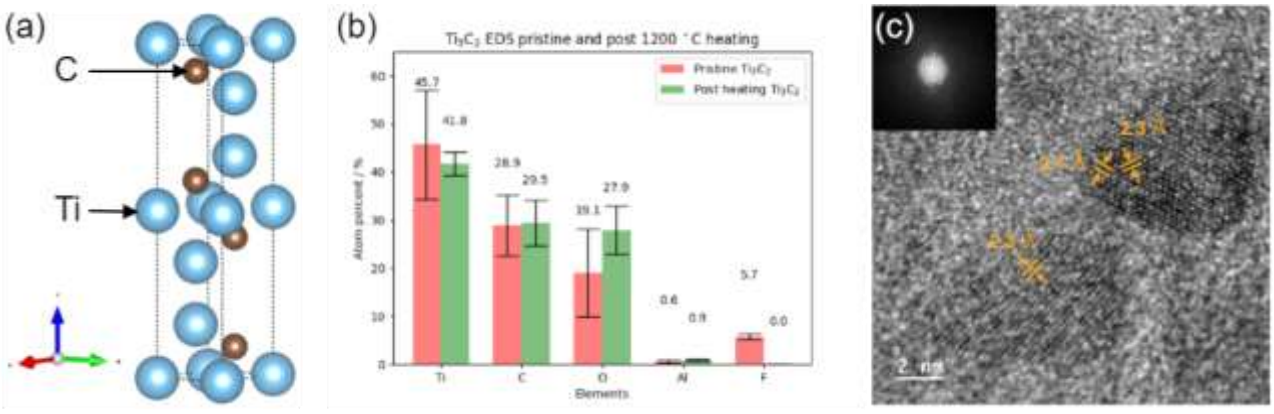

Figure 1: (a) Unit cell of $Ti_3C_2T_x$. (b) EDS data of pristine compared to post heating of the $Ti_3C_2T_x$ sample. (c) High resolution TEM image showing grains of TiC formed in $Ti_3C_2T_x$ Sheets with inset image of FFT.