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Phase transformations of a desert sand to a calcia magnesia aluminosilicate (CMAS) deposit: a Synchrotron powder diffraction study

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Thermal barrier coatings (TBC) are porous layers designed to insulate and protect turbine blade and vanes from the hot and oxidising gases in gas turbine engines. Dust or volcanic ash particles ingested by the engine can melt and form calcia-magnesia-alumino-silicate (CMAS) deposits on the TBC. During further engine operation the molten deposits can infiltrate the porous TBC and chemically interact. On engine shut-down the CMAS solidifies to create a TBC that is less porous and compliant and prone to delaminate as the engine cools down. Without TBCs, the blades and vanes need to be replaced pre-maturely, increasing costs.

To investigate the chemical processes of CMAS formation and CMAS+TBC interaction, we performed a synchrotron powder diffraction study on oxide-mineral rich desert sand and standard TBC zirconia powder. One set of diffraction patterns were collected in real time as a sample was heated and cooled through the range of 25-1400℃ while in the diffractometer. These patterns were compared to powder mixtures previously heated in a furnace at 1100 and 1300℃ for 4hrs.

The results indicated the temperatures at which the desert sand underwent transformations. They also showed that the sand can react with the TBC zirconia to form zircon (ZrSiO4) and increase the amount of monoclinic zirconia. TBCs are manufactured to consist of tetragonal zirconia as coatings made from monoclinic zirconia break apart on thermal cycling. Overall the diffraction study helped to further define the mechanisms by which CMAS attacks TBC.

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