

# RE<sub>2</sub>O<sub>3</sub> DISSOLUTION KINETICS AND MECHANISMS IN GAS SILICATE MELTS: INFLUENCE OF THE RARE-EARTH

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Fine particles of sand, dust or volcanic ashes ingested by aircraft engines are well-known to damage 8YPSZ Thermal Barrier Coating (TBC). In service, these particles deposit on hot TBC surface ( $\geq 1200^\circ\text{C}$ ) as molten silicate and infiltrate coating porous microstructure. They are mainly constituted of CaO-MgO-Al<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub> (CMAS) in variable proportions and also contain metallic oxides. Gd<sub>2</sub>Zr<sub>2</sub>O<sub>7</sub> TBC has shown efficiency to mitigate synthetic CMAS infiltration due to its reactivity with CMAS [1]. Indeed, the dissolution reaction leads to rapid formation of a sealing-layer in the topcoat mainly constituted of crystalline Ca<sub>2</sub>Gd<sub>8</sub>(SiO<sub>4</sub>)<sub>6</sub>O<sub>2</sub> apatite. However, this phase is not always stable in contact with CMAS and many rare-earth silicates may compete with apatite crystallization [2]. Several rare-earth oxides RE<sub>2</sub>O<sub>3</sub> can be considered to replace yttria in ZrO<sub>2</sub>-based TBC but little is known on reaction kinetics and thermodynamics involving RE<sub>2</sub>O<sub>3</sub> and multi-component CMAS system.

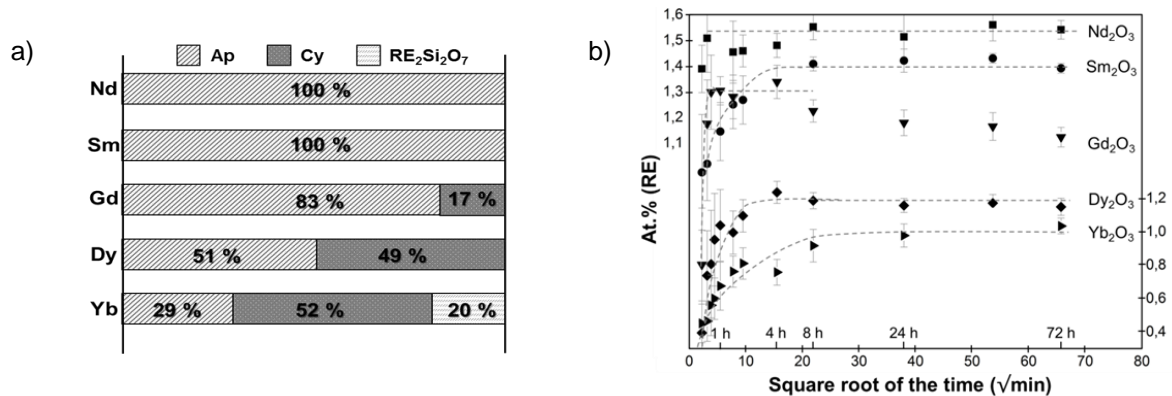


Figure 1 – a) RE-silicates proportion in RE<sub>2</sub>O<sub>3</sub>/CAS-bead mixtures after 1h at 1200°C and b) RE<sub>2</sub>O<sub>3</sub> dissolution kinetics measured by EPMA (1200°C)

In this study, a simplified CMAS was selected with eutectic (1170°C) 65SiO<sub>2</sub>-26CaO-9Al<sub>2</sub>O<sub>3</sub> (mol. %) composition. Investigation on RE<sub>2</sub>O<sub>3</sub> (RE = Nd, Sm, Gd, Dy and Yb) dissolution mechanism in CAS-melt was then performed at 1200°C. For this, CAS-glass beads containing dispersed RE<sub>2</sub>O<sub>3</sub> solid powder in adequate amount to reach oversaturation were elaborated. Beads were then annealed in air for several durations and quenched. SEM observations coupled with XRD analysis gave information about dissolution/precipitation sequences and phase equilibria. The evolution of RE content dissolved in CAS over time and chemical evolution of CAS-melt was measured by EPMA. Reaction mechanism in CAS of RE<sub>2</sub>O<sub>3</sub> was identified to be incongruent dissolution leading to precipitation of different RE-rich silicates. Dissolution of Nd<sub>2</sub>O<sub>3</sub>, Sm<sub>2</sub>O<sub>3</sub>, Gd<sub>2</sub>O<sub>3</sub> and Dy<sub>2</sub>O<sub>3</sub> in CAS results in formation of metastable apatite, and then stabilization of cyclosilicate. Disilicate Yb<sub>2</sub>Si<sub>2</sub>O<sub>7</sub> was also obtained in Yb<sub>2</sub>O<sub>3</sub> bead-sample. The silicate precipitations induced significant variations of local CAS composition resulting in CaAl<sub>2</sub>Si<sub>2</sub>O<sub>8</sub> anorthite formation. The RE<sub>2</sub>O<sub>3</sub> basicity has a direct influence on silicates solubility limits in CAS and on reaction kinetics (Fig.1).

[1] S. Krämer et al., Journal of the American Ceramic Society, 91 (2008) 576-583

[2] D.L. Poerschke et al., Journal of the European Ceramic Society, 36 (2016) 1743–1754

[3] F. Perrudin et al., Journal of the European Ceramic Society, 37 (2017) 2657–2665