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# Solubility of oxides from $ZrO_2$ - $Y_2O_3$ and $ZrO_2$ - $Nd_2O_3$ systems in a molten CAS. Selection of a thermal barrier composition resistant to CAS infiltration

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## **SOLUBILITY OF OXIDES FROM $ZrO_2$ - $Y_2O_3$ AND $ZrO_2$ - $Nd_2O_3$ SYSTEMS IN A MOLTEN CAS. SELECTION OF A THERMAL BARRIER COMPOSITION RESISTANT TO CAS INFILTRATION**

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Thermal barrier coatings (TBCs) are routinely used to protect blades and vanes in the hot section of gas turbines. TBCs are multilayered systems including a thermal insulating porous ceramic layer mostly of 8wt. % (4mol.%) yttria partially stabilized zirconia 8YPSZ, deposited on an alumina forming metallic bond coat in contact with the nickel-based superalloy substrate. The use of TBC has allowed higher operating temperatures resulting in an improvement in engine efficiency. However, with the increase in the engine temperature new TBC degradation mechanisms has emerged such as the attack by molten calcium-magnesium alumino silicate (CMAS) resulting from the ingestion of siliceous minerals (dust, sand, ash) by the engine. The molten particles can infiltrate the porous microstructure of the TBC resulting in the loss of strain tolerance and premature failure of the TBC. Chemical interaction also takes place consisting in the dissolution of 8YPSZ in the molten CMAS followed by precipitation of new crystalline phases. In this paper, we first present the thermodynamic and kinetic study related to the dissolution into a synthetic CAS of different oxides from the  $ZrO_2$ - $Y_2O_3$  and  $ZrO_2$ - $Nd_2O_3$  systems. Solubility tests were performed according to an experimental process developed at University of Lorraine. The chosen oxides, in powder form, are the pure oxides  $ZrO_2$ ,  $Y_2O_3$ ,  $Nd_2O_3$ , the compounds  $ZrO_2$ -4%mol  $Y_2O_3$ ,  $ZrO_2$ -10%mol  $Y_2O_3$ ,  $ZrO_2$ -12%mol  $Nd_2O_3$  and the pyrochlore  $Zr_2Nd_2O_7$ . Solubility tests were performed at three temperatures 1200°C, 1300°C and 1400°C at durations varying from 5 min to 4h. It is observed that: i)  $ZrO_2$  dissolves gradually in the CAS with the slow formation of zircon ( $ZrSiO_4$ ). ii)  $Nd_2O_3$  and  $Y_2O_3$  dissolves much more fastly in the CAS than  $ZrO_2$  and the formation of the apatite phase  $X_8Ca_2(SiO_4)_6O_2$  ( $X = Nd$  ou  $Y$ ) is observed in the first minutes of interaction. The solubility limit of  $Y_2O_3$  is higher than  $Nd_2O_3$  one. iii) the fast formation of the apatite phase is also observed during the dissolution of  $ZrO_2$ -12%mol  $Nd_2O_3$  and  $Zr_2Nd_2O_7$  but not during the dissolution of yttria doped zirconia. It is concluded that higher amount of yttria should be added to zirconia in order to promote the formation of the apatite phase  $Y_8Ca_2(SiO_4)_6O_2$ . In a second time, 5 compositions of zirconia- based dense ceramics are tested as regards to CAS infiltration: three with increasing amount of yttria and the two previous neodymia doped zirconia. It is observed that the infiltration of CAS in the ceramic grain boundaries is stopped in the case of neodymia doped zirconia and with the zirconia allied with the higher amount of yttria. This type of research provides new insight into the understanding of CMAS mitigation strategy based on zirconia doped with rare earth oxides or on rare-earth zirconates.