CMAS INTERACTION WITH YTTRIUM BASED SYSTEMS: TOWARDS A PROMISING SOLUTION?

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Anti-CMAS coatings are designed to protect thermal barrier coatings against degradations due to CMAS infiltration. They are dedicated to react as fast as possible with CMAS compounds in order to generate a new phase that will not let the CMAS infiltration going on. In addition to the fast kinetics, the preparation of large quantities of phases with as less as anti-CMAS material as possible is sought as well as the obtaining of a dense and impermeable phase. Reference anti-CMAS material is gadolinium zirconate, it has been demonstrated as efficient to block CMAS infiltration. The efficiency of yttria for the same application has been studied by previous works at the CIRIMAT laboratory [1]. The starting point of this work was first, to make a comparative study of the anti-CMAS properties of gadolinium zirconate and yttria based anti-CMAS compositions and secondly, to discuss on the behaviour of a mixed composition i.e. yttrium zirconate. This insight on the mechanism of interactions of CMAS with the yttrium based systems and gadolinium reference is obtained at the light of a large number of interactions experiments and characterizations. Interaction durations between 1h and 100h were investigated, with either 50/50 or 80/20 mass ratio of CMAS/anti-CMAS. Different temperatures of interaction between 1200°C to 1300°C were also scanned. The phases in presence were systematically characterized by XRD, SEM, EDX and Castaing microprobe local analyses and cartographies (*Figure 1a)*). In particular, the proportion and composition of phases are detailed as a function of the interaction time (*Figure 1b)*) for each anti-CMAS-CMAS interaction system. From these experiments, the mechanisms of interaction between CMAS and Y_2O_3, $Y_2Zr_2O_7$ and $Gd_2Zr_2O_7$ are evidenced. Whereas Y_2O_3 interaction leads to the higher proportion of reaction products, the products impermeability is also superior for this composition. The depth of infiltration of CMAS into a dense pellet anti-CMAS material for a given time is longer for $Y_2Zr_2O_7$ as compared to the two others. However $Y_2Zr_2O_7$ benefit is due to a higher Ca^{2+} trapping capability with the formation of Ca_4Y_6 like phase instead of Ca_2Y_8 for Y_2O_3 (*Figure 1c)*). In this respect, yttrium zirconate demonstrates a synergetic effect as compared to Y_2O_3 and $Gd_2Zr_2O_7$. The origin of this synergy is interpreted as coming from the presence of both zirconium and yttrium. A large part of the discussion is based on the study of powders interactions, an insight into the interactions of CMAS with anti-CMAS pellets of the different compositions will also be presented and discussed. Fundamental and applicative aspects will be covered.

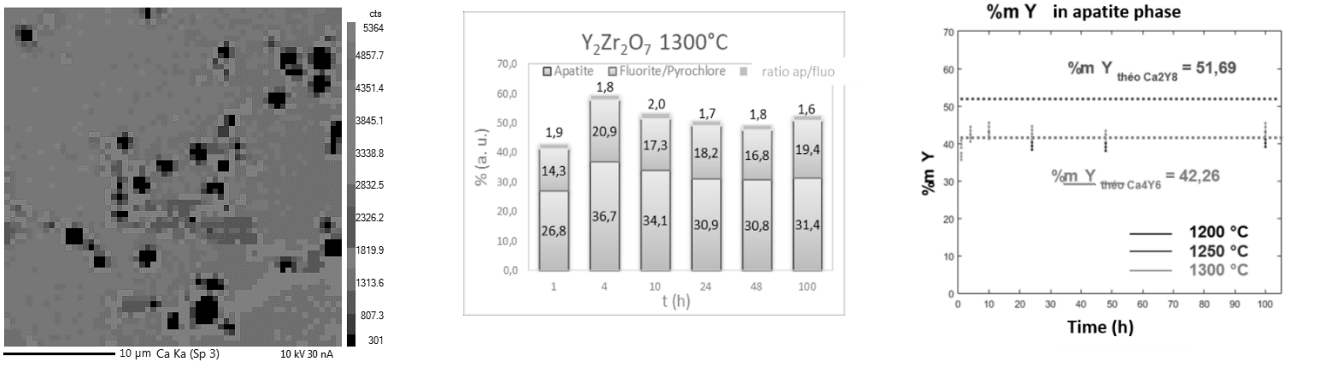

Figure 1 – a) Ca^{2+} element mapping by Castaing microprobe for $Y_2Zr_2O_7$ powder after 1h interaction with model CMAS at 1300°C b) Surface repartition of apatite and fluorite phases for $Y_2Zr_2O_7$ in interaction with the model CMAS for interaction times from 1h to 100h at 1300°C, c) Mass ratio of yttrium in the apatite phase as a function of the interaction time between $Y_2Zr_2O_7$ and the model CMAS, the theoretical limits of mass ratio corresponding to Ca_2Y_8 and Ca_4Y_6 phases are given.

[1] E. Delon, F. Ansart, S. Duluard, J.P. Bonino, A. Malié, A. Joulia, P. Gomez, Synthesis of yttria by aqueous sol-gel route to develop anti-CMAS coatings for the protection of EBPVD thermal barriers, Ceramics International, 42 (2016), 13704-13714