FIBERS AND SOL-GEL MATRIX BASED THERMAL BARRIER COATING SYSTEMS FOR OUTSTANDING DURABILITY

Sandrine Duluard, CIRIMAT, Université de Toulouse, CNRS, Université Toulouse 3 Paul Sabatier, France
duluard@chimie.ups-tlse.fr
Elodie Delon, CIRIMAT, Université de Toulouse, CNRS, Université Toulouse 3 Paul Sabatier, France
Florence Ansart, CIRIMAT, Université de Toulouse, CNRS, Université Toulouse 3 Paul Sabatier, France
Jean-Pierre Bonino, CIRIMAT, Université de Toulouse, CNRS, Université Toulouse 3 Paul Sabatier, France
Daniel Monceau, CIRIMAT, Université de Toulouse, France
Aurélie Rouaix-Vande Put, CIRIMAT, Université de Toulouse, France
Ronan Mainguy, CIRIMAT, Université de Toulouse, France
Carole Thouron, CIRIMAT, Université de Toulouse, France
Aurélien Joulia, SAFRAN Tech, Pôle Matériaux et Procédés, rue des Jeunes Bois, 78772 Magny-Les-Hameaux
André Malié, SAFRAN AIRCRAFT ENGINES Site de Chatellerault, France
Luc Bianchi, SAFRAN AIRCRAFT ENGINES Site de Chatellerault, France
Philippe Gomez, DGA Techniques aéronautiques, France

Key Words: Ceramic fibers, Sol-gel, Thermal barrier coatings, Cyclic oxidation, Durability

Thermal barrier coatings (TBC) are critical elements of the turbomachines. On turbine blades for aircraft engines, their preparation is based on EB-PVD industrial process. Such TBCs on first generation AM1 superalloy with a beta-NiPtAl bond coating exhibit 20% of surface spallation after about 600 1h oxidation cycles at 1100°C. In this work, a new method of TBC preparation was proposed and high durability of such structures was obtained with more than 1000 1h cycles at 1100°C before 20% of spallation. More than 1400 1h cycles was even obtained with the most performing formulations. A key point was that the surface spallation was lower than 10 % after 1000 cycles for TBCs made with the 70% and 80% fiber mix (*Figure 1a*). In the same conditions, EB-PVD TBCs exhibit 50-80% of spallation. The preparation process relied on the addition of a high temperature binder, namely a zirconia sol, to a mix of zirconia powder and fibers. TBCs with equiaxed porosity were obtained (*Figure 1b*). After thermal treatments, ceramic sintering bridges between the powder, the fibers and the ceramic derived from the sol transformation formed (*Figure 1c*). Another benefit was obtained from the anchoring of the fibers in the thermally grown oxide (TGO), inducing a tougher TGO layer. The outstanding durability of these fibers and sol-gel matrix based thermal barrier coatings is believed to be the consequence of higher toughness of both the TBC coating and modified TGO. Indeed, crack deviations were observed in these two elements. Moreover, contrary to EB-PVD TBCs, the porosity is isotropically distributed, limiting heat diffusion towards the superalloys.

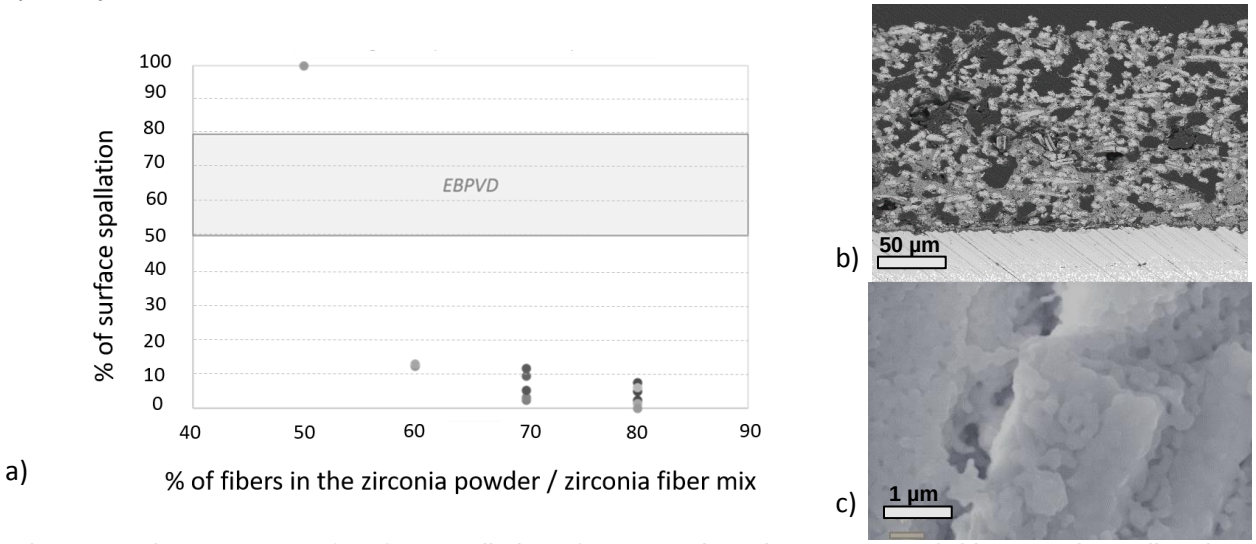

Figure 1 – a) Percentage of surface spallation after 1000 1h cycles at 1100°C (with a 15 min cooling down to room temperature) versus the percentage of fiber in the zirconia powder/ fiber mix. The average values for industrial EB-PVD are given as a reference (specimen provided by Safran group). b) SEM micrograph of the cross-section of a 70%m fibers sol-gel TBC c) SEM micrograph of ceramic sintering bridges in the fiber based TBCs after heat treatment at 1250°C.