# SiC-based/EBC COATING SYSTEMS INVESTIGATED BY LASAT (LASER SHOCK ADHESION TEST)

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LASAT (LAser Shock Adhesion Test) is a laser-driven mechanical method that has been developed to evaluate the interface strength of ceramic coating involving the so-called ‘white spot’ debonding diagnosis. This diagnosis is mostly suitable for semi-transparent and reasonably thick ceramic coatings, e.g. like thermal barrier or bioceramic coatings [1,2]. With LASAT, a compressive shock wave followed by a rarefaction wave are generated by a nanosecond laser pulse. When implemented on the substrate side, both waves propagate and reflect when crossing interfaces and when reaching the coating surface. Tensile stress is induced in the region where, and during the time when, the incident rarefaction wave and the reflected release wave intersect. For a given energy level, this tensile stress can generate a macroscopic internal damaging especially in low toughness regions like interfaces. In case of interfacial failure, the aim of LASAT is to provide a debonding threshold for a corresponding laser fluency given in GW/cm². A LASAT-induced interfacial crack could also be deliberately introduced as a calibrated internal crack for further monitoring of its propagation under any applied loading and using nondestructive imaging [3].

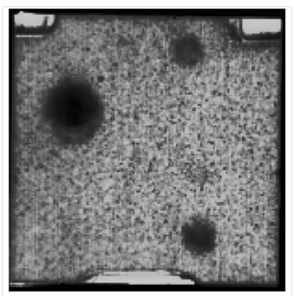

*Figure 1 – IR image after LASAT on EBC*

In the frame of advanced gas turbine technology exhibiting higher thermal capability, ceramic matrix composites (CMCs) like $SiC_f/SiC$ offer many advantages but an Environmental Barrier Coating (EBC) by thermal spray is necessary to protect the structural ceramic for a high-temperature environment [4]. In this work, different EBC systems with different ceramic top layers (nature, thickness) in the as-sprayed condition and after a crystallization heat-treatment were investigated by LASAT. In order to better learn about the role of the Si-based ceramic substrate on the implementation of LASAT, different substrates involving $SiC_f/SiC$ or bulk SiC substrates with various thicknesses were also prepared and submitted to a series of laser shocks with increasing energies. The presence of internal damages was analysed non-destructively by imaging the ceramic top-surface by infra-red thermography with flash or maintained heating (*Figure 1*). The actual position and length of the cracks were assessed post-mortem by SEM on cross-sectioned EBC samples (*Fig.2*). It allowed establishing the influence of the EBC samples' nature, dimension, and post-treatment on the implementation of LASAT and on the resulting locations of low toughness regions. These damaging behaviours can be discussed according to the knowledge of the temporal and spatial distribution of stress. To that end, Xt diagrams (*Fig.3*) were calculated by 2D-axisymmetric FEM involving linear acoustic assumptions. This first attempt of LASAT on EBC systems was reliable. It revealed two regions possibly damaged by LASAT with sufficient energy, i.e. in the ceramic and at the Si/EBC interface.

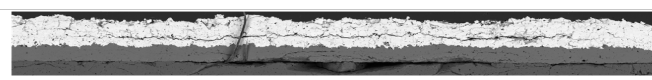

*Figure 2 – cracks induced by LASAT on EBC*

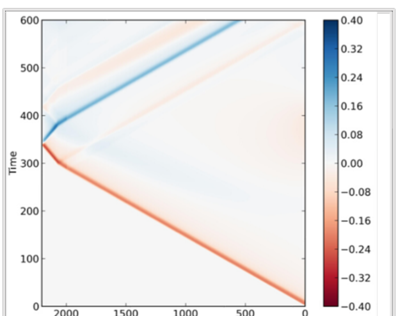


*Figure 3 – Xt diagram SiC/EBC*

[1] G. Bégué et al., Laser Shock Adhesion Test (LASAT) of EB-PVD TBCs: Towards an industrial application, Surf. Coat. Technol. 237 (2013) 305–312.
[2] V. Guipont et al., Bond strength determination of hydroxyapatite coatings on Ti-6Al-4V substrates using the LAser Shock Adhesion Test (LASAT), J. Biomed. Mater. Res. A. 95A (2010) 1096–1104.
[3] V. Maurel et al., Thermal cycling damage monitoring of thermal barrier coating assisted with LASAT (LAser Shock Adhesion Test), Surf. Coat. Technol. 380 (2019) 125048.
[4] E. Bakan et al., $Yb_2Si_2O_7$ Environmental Barrier Coatings Deposited by Various Thermal Spray Techniques: A Preliminary Comparative Study, J. Therm. Spray Technol. 26 (2017) 1011–1024.