EXPERIMENTAL INVESTIGATION OF ABLATIVE MATERIALS IN PLASMATRON

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CONFIDENTIAL REPORT

Ablators protect a space vehicle from severe heating during the reentry phase into the Earth atmosphere with very complex processes which are especially for new light-weight, composite materials not completely understood up to this day. Within this project both, free-stream characterisation of the plasma flow as well as observation of the ablation process demonstrated the successful application of a comprehensive experimental setup providing a new methodology in ablation testing in the VKI Plasmatron facility.

By doing so, the degradation of the sample, such as surface recession, mass loss and pyrolysis as well as the chemical composition of these outgassing products and their subsequent reactions undergone with the free-stream gas were investigated. Recession was measured by pre- and post-test sample evaluation (calliper rule) as well as in-situ using a high speed camera (HSC, fig. 1 and fig 2 (a)). This showed new promising results for the evaluation of recession speed during the test with applying contour detection what offers a new technique.

Differences were found for both, sample degradation and time-resolved emission spectra depending on air or nitrogen test gases due to varying reactions undergone. This lead to discrepancies in mass loss and recession, what suggested a higher contribution to mass consumption by in-depth decomposition than the removal of mass caused by ablation of the outer char layer.

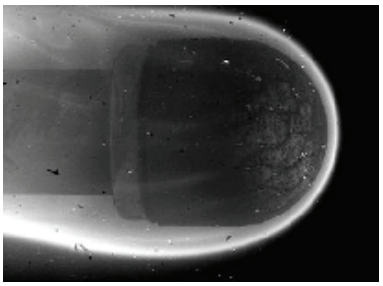

Figure 1: Ablation image (HSC)

With the measurements obtained from emission spectroscopy in front of the ablating sample, it was shown that nitridation leading to *CN* (*CN violet*&*CN red*) is highly apparent in pure nitrogen plasma flows (Figure 2b) but significantly drops if oxygen is involved (Figure 2c), speaking for dominant oxidation reactions (*CO, CO_2, NO*). This binding strength of carbon with oxygen rather than the formation of carbon nitride was also demonstrated with a simplified thermo-chemical model for a *C, N &O* mixture (thermo-chemical library MUTATION).

As expected, oxygen is the driving force to provoke reactions as the system undergoes the ablation process, but its uncertain state of diffusion into the porous material and on the contrary, reactions undergone in the absence of oxygen, call for more investigation.

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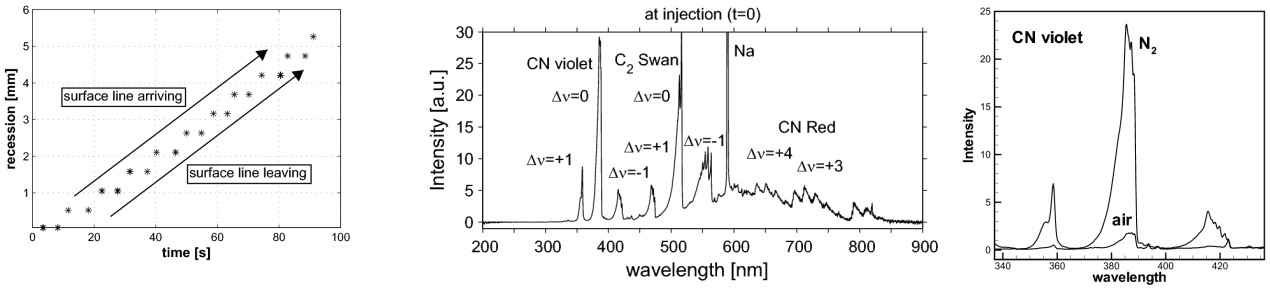

(a) Recession measured with HSC *(b) Ablation spectrum in N_2 plasma* *(c) CN in N_2& air plasma*

Figure 2: Results of ablation tests