ToF-SIMS Analysis of Paint Craters

Surface analysis by Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) gives unique insights into the chemical composition of paint crater surfaces. Both the elemental and the molecular composition can simultaneously be probed and excellent detection limits are achieved. Thus it is possible to discriminate between different sources for crater formation on a short time scale bringing production on-line again fast.

Craters are serious defects in paint quality especially in the automotive industry. Crater occurrences have a tremendous economical impact not only with respect to the total costs involved (stop of production, repair efforts) but also with respect to the customer confidence in the respective paint supplier. An expeditious analytical elucidation of the causes for crater formation is therefore indispensable.

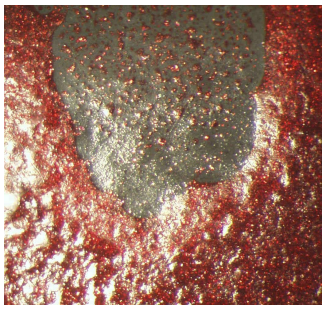

Figure 1: Optical image of a crater in car paint

Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) is a surface analytical tool which gives information on the elemental and molecular composition of surfaces. Being an imaging technique it can best be described as a "chemical microscope" delivering compositional maps of the surfaces of interest.

Figure 1 shows the optical image of a crater in car paint. Thorough optical and light microscopy inspection (surface, section) should always be the first step in crater analysis and already gives clues to possible damage causes Craters in car paint occur at locations of different wetting behaviour. If optical inspection makes it likely that a contaminant has lowered the surface tension of the substrate material, ToF-SIMS is the analytical tool of choice for further specifically tailored analysis. Not only can it probe the chemical composition with high sensitivity in a localised manner (ToF-SIMS imaging) but it samples the information exclusively in the uppermost 1-3 atomic and molecular layers of a surface making it very surface sensitive.

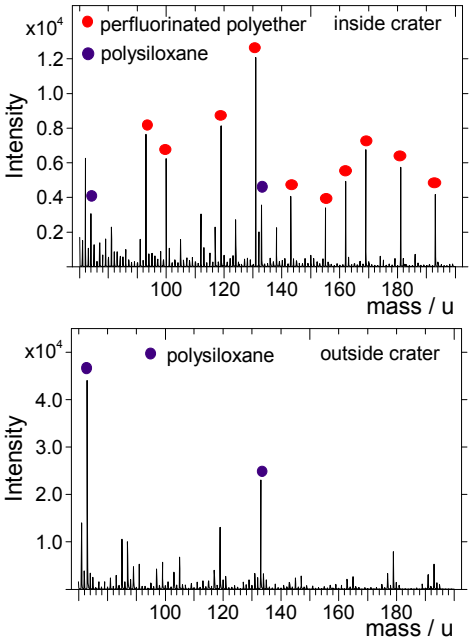

Figure 2: ToF-SIMS spectra (positive secondary ion polarity) taken inside and outside the crater of Figure 1.

Figure 2 shows the results of a localized ToF-SIMS analysis inside and outside the crater of Figure 1. The mass spectrum at both positions is dominated by polysiloxane in this case being a liberate constituent of the topmost paint layer. Note that polysiloxanes can also be the cause of

crater formation and ToF-SIMS generally is able to distinguish between different siloxane types.

Inside the crater additionally a perfluorinated polyether can be identified. Perfluorinated polyethers are high performance lubricants e.g. used in robot systems or transport belt systems. Minor amounts are sufficient to disturb the wetting behaviour in paint systems. Note that even powerful surface analytical techniques like X-ray photoelectron spectroscopy (XPS) are not sensitive enough to detect perfluorinated polyethers at a concentration level already negatively influencing paint spreading.

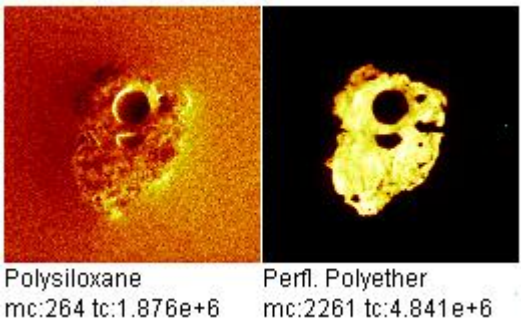

Figure 3: Mass resolved ToF-SIMS images of a crater similar to that of Figure 1; positive secondary ion polarity; field of view: 240 x 240 µm²

Figure 3 shows laterally resolved secondary ion images of a paint crater similar to that of Figure 1. A colour-coded intensity is used to represent ion intensities with bright colours corresponding to high and dark colours corresponding to low intensities.

Clearly, the presence of the perfluorinated polyether in the centre of the crater is visible confirming the results of surface spectrometry as presented in Figure 2.

Besides silicones and polyethers, the following materials relevant to car paint can successfully be identified by ToF-SIMS:

- inorganic species (elements (e.g. metals), salts, sulphates, phosphates, nitrides etc.)
- small particles (nanoparticles)
- lubricants
- oils
- fatty acids and related compounds
- polymer matrices and additives
- paint additives (e.g. catalytic species)
- cleaning agents