Application note

Laser ablation for high-quality cross-sectioning of auto body paints

Multi-layered auto body coatings have two main functions; protecting the vehicle body from corrosion and making the car aesthetically pleasing.

Automotive painting is also operationally the most expensive part of automobile assembly. Industrial practitioners and researchers are greatly interested in controlling and monitoring the painting process (e.g., layer thickness, chemical composition, etc.) in order to improve the quality of coatings and their mass production. In this application note, we demonstrate a novel approach for high-throughput automated cross-sectioning of car paint coatings using the Thermo Scientific™ Helios™ 5 Laser Plasma FIB.

Traditionally, paint quality is determined by analyzing paint coating samples that are embedded in polymer resin blocks. Multi-step mechanical polishing is used to produce a cross-section of the paint on a steel body substrate. This approach is, however, time-consuming and makes it difficult to produce the extremely smooth surfaces needed for high-quality analysis. Gallium focused ion beam (FIB) milling can only reasonably produce 20 µm wide and deep cross-sections of samples, making it unsuitable for accessing paint samples, as the paint layer thickness can be more than 100 µm. Creating pristine cross-sections wider and deeper than a few hundred microns is even time-consuming for xenon plasma FIB as it requires low-current polishing and the application of a thick protective layer prior to cross-sectioning.

The Helios 5 Laser Plasma FIB combines a fully integrated femtosecond laser, scanning electron microscope (SEM), and FIB. The laser enables fast, millimeter-scale material removal without the need for a protective layer, while combined SEM and EDX (energy-dispersive X-ray spectroscopy) can be used to reveal structural and chemical details of the paint layers. This allows for fast feedback during auto body coating quality control.

Helios 5 Laser PFIB.

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EDX results show that cross-section chemical information is not altered by the in-chamber laser ablation process.

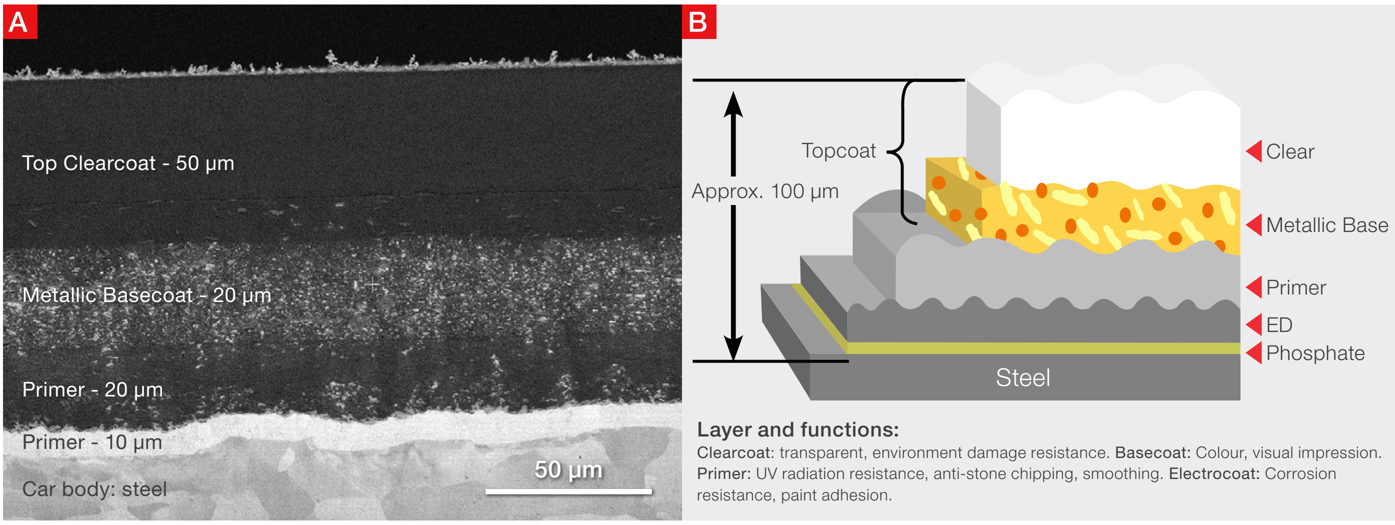

Figure 1. A) SEM backscattered electron image of an auto body coating cross-section. B) Typical four-layer automotive paint structure. *Schematic drawing is modified, with permission, from Akafuah, N, Poozesh, S, et al. Evolution of the Automotive Body Coating Process—A Review. Coatings, 6(2), 24. 2016. doi:10.3390/coatings6020024*

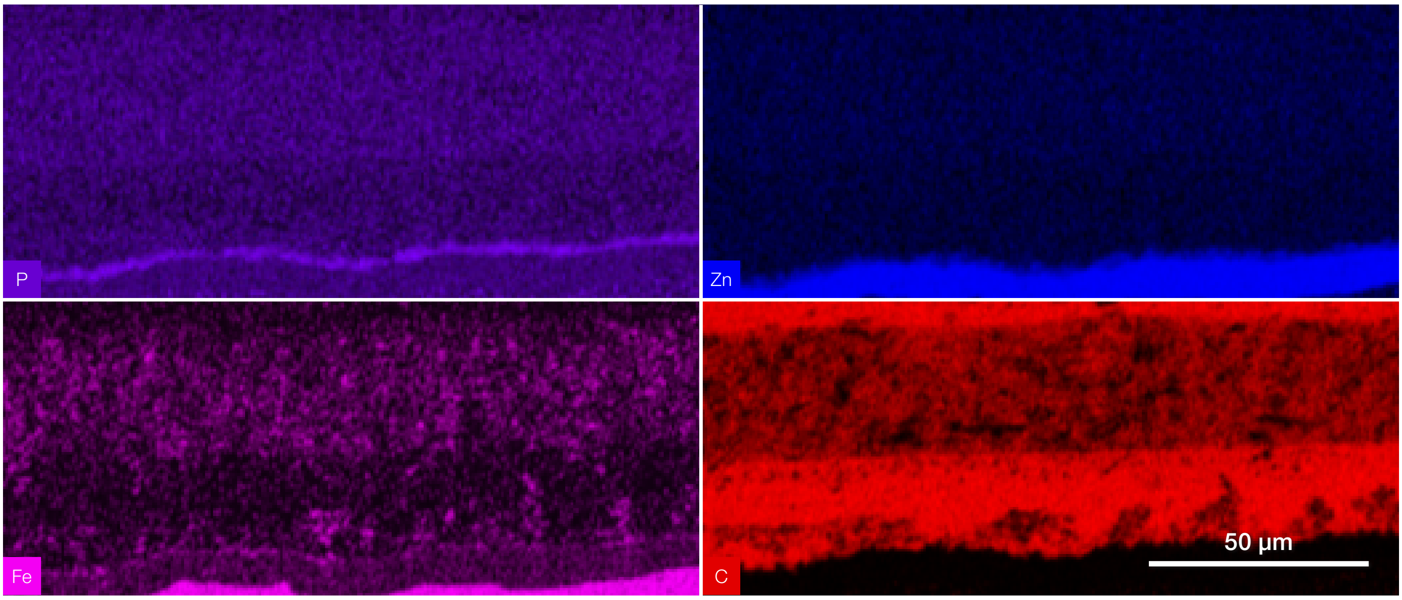

Figure 2. EDX elemental maps clearly correlate to the paint structure shown in Figure 1. Both cross-section preparation and imaging were performed using the Thermo Scientific Helios 5 Laser Plasma FIB. The cross-section was prepared using only the integrated in-chamber laser, without a PFIB clean up step. This demonstrates the high quality of femtosecond laser processing and enables the instrument to maintain high-throughput characterization.

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