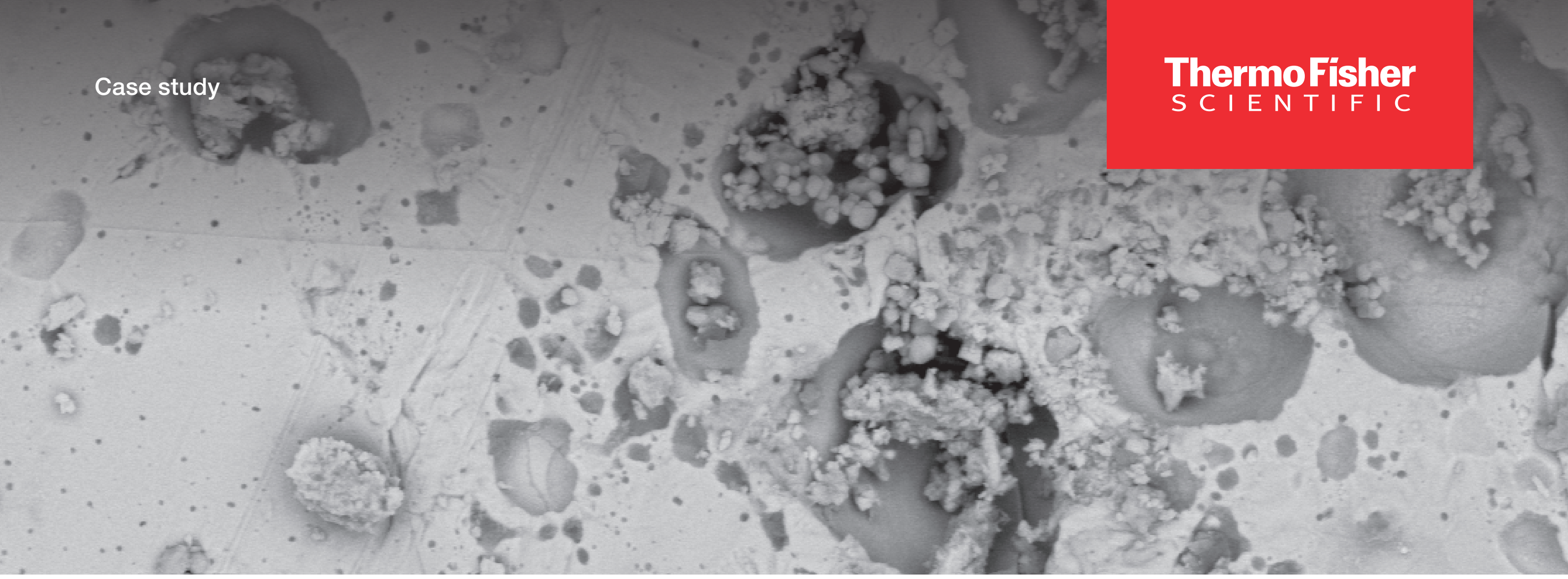

Case study

Shielding titanium: The quest for high-temperature resilience

How advanced SEM technology is revolutionizing titanium alloy coatings

The problem

Known for their strength and lightweight properties, titanium alloys are ideally suited to aerospace applications. However, they are prone to failure at temperatures above 500°C. This significantly limits their industrial use, especially in aerospace engines.

While titanium alloys can form a dense oxide layer on their surface to prevent further oxidation at temperatures below 500°C, this protective layer becomes porous as the temperature rises. The porosity allows oxygen to diffuse into the titanium alloy, which causes oxides to form over time and eventually leads to failure.

The impact

The failure of titanium alloys at high temperatures can have several consequences. As the alloys are used for key components in expensive aerospace equipment, repairs are costly and typically come with extended downtime. The components are checked regularly for signs of weakening and becoming brittle, which results in cracks and fractures. This process is highly temperature dependent, so it's difficult to predict and a safety risk in itself.

The challenge

To mitigate these risks, it's essential to use protective coatings on titanium alloys. These coatings act as a barrier between the alloy and the environment, reducing corrosion and oxidation. However, developing structurally dense, highly oxidation resistant $MoSi_2$ coatings on titanium alloy surfaces is a significant challenge, as even minor coating defects can have a big impact on the alloy substrate.

The solution

To address this challenge, the Thermo Scientific™ Phenom Pharos™ Desktop Scanning Electron Microscope with EDS can be used to analyze the performance of $MoSi_2$ coatings on titanium alloys. The instrument provides the necessary capabilities for this analysis, including a field emission source, resolution better than 2 nm, and an integrated high-performance EDS detector.

The results

In one sample, the $MoSi_2$ coating layer was approximately 800 nm thick and cracks in the coating were less than 100 nm wide. The diffusion and distribution of elements near these defects needed to be analyzed to fully understand the coating's performance.

The Phenom Pharos Desktop SEM's high-performance EDS made it possible to map individual elements present in the sample. The silicon and molybdenum maps confirmed the presence of the $MoSi_2$ layer on most of the alloy's surface. However, both elements were absent from the defect. The oxygen map proved the coating's effectiveness, showing that, in the coated areas, no oxygen diffused into the substrate of Ti_6Al_4V. Elemental mapping of the defect showed the presence of oxygen, titanium, and vanadium, confirming that oxygen diffused into and oxidized the substrate within the crack. The results help to illustrate that the oxide layer of silicon is crucial in enabling the $MoSi_2$ coating to act as an effective barrier.

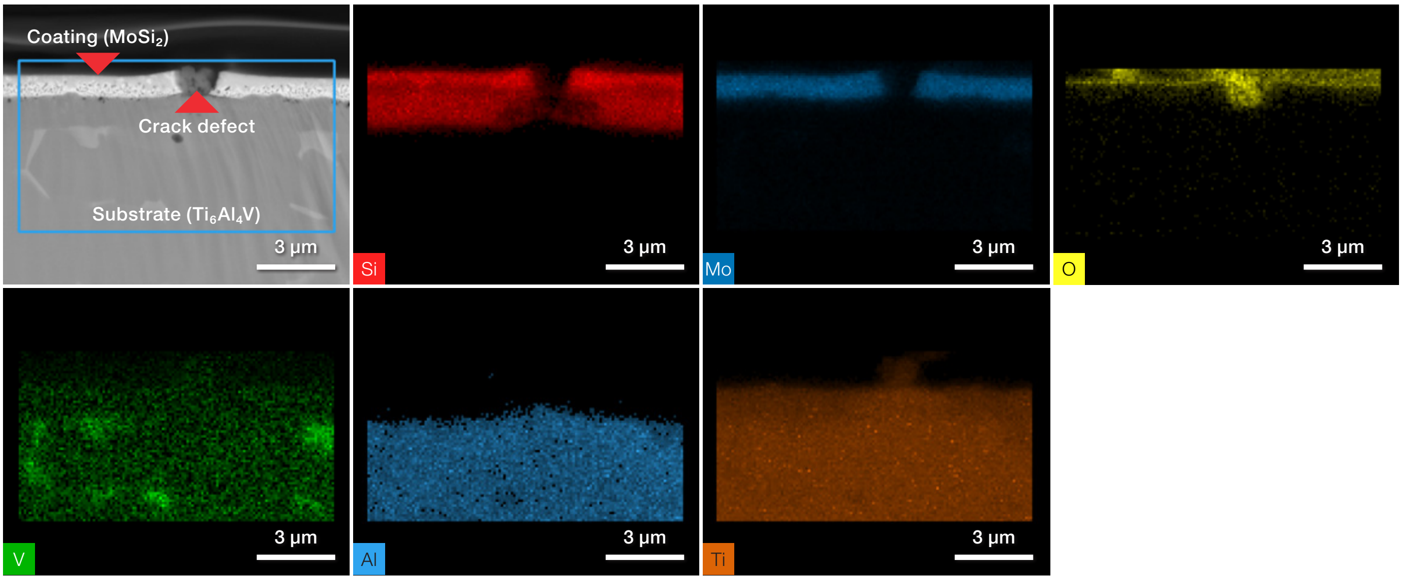

Figure 1. EDS map of the titanium alloy coated with $MoSi_2$ after a high-temperature resistance test conducted at 700°C.

Conclusion

The Phenom Pharos Desktop SEM with EDS plays a pivotal role in studying and developing titanium alloy coatings. By providing detailed insights into the thickness, density, and uniformity of the $MoSi_2$ coatings, as well as identifying and analyzing defects, this advanced SEM technology delivers data that can help you ensure that titanium alloys can withstand high-temperature environments.

Advanced SEM technology is key in developing next-generation coatings that enhance the resilience and reliability of titanium alloys in extreme conditions. By shielding titanium from the perils of high temperatures, we pave the way for safer and more efficient aerospace applications.

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