Preventing thermal degradation of selective absorber coating for concentrating solar collector applications

THE INDUSTRIAL CHALLENGE

Heating and cooling accounts for half the global energy consumption, making a shift towards renewable thermal energy production essential for counteracting climate change. Absolicon contributes to this transition by developing and producing the most efficient parabolic trough solar collector in the world. Further improvement through material research is the key in successfully outcompeting fossil fuel alternatives. Towards this goal, Absolicon have developed and patented a new coating for the receiver, the component that absorbs the solar energy and converts it to heat. The selective cobalt-chromium coating, see figure 1, exhibit excellent optical properties, and the next step towards industrialization is to ensure the durability of the coating. At elevated temperatures, oxidation and diffusion has been observed to degrade the optical properties of the coating. The oxidation is efficiently prevented with a silica top coating, but a better understanding of the Cr diffusion is needed to determine how to solve the issue.

WHY USING A LARGE SCALE FACILITY

The coating and its degrading processes have been thoroughly analysed with lab-based X-ray techniques, e.g. XRD and XPS for the average coating structure and chemical states. In addition, the local structure and chemical distribution were studied via TEM (transmittance electron microscopy) with EELS (electron energy loss spectroscopy) and EDX (energy-dispersive X-ray spectroscopy). However, due to the low concentration, challenging sample preparation, and the demands on high spatial resolution, the Cr-layer in the coating has not yet been identified. Thus, the hard X-ray imaging techniques with a larger probing depth at the synchrotron radiation facilities may provide low enough detection limits at a high enough spatial resolution to allow studies of induced chemical changes of the coating at elevated temperature.

The techniques of interest are scanning imaging which uses a small X-ray beam spot rasterring over specimens and creates the image contrast via the variation of scattering or spectroscopy signals. Scattering provides information of the structure and morphology, e.g. crystalline phase, orientation, etc, of the coating and how this is changed during degradation, while XAS (X-ray absorption spectroscopy) could provide information on the induced changes in the chemical form of Co and Cr. Furthermore, chemical mapping with nano-XRF (X-ray Fluorescence) would allow studies of the diffusion of Cr. By combining the two (nano-XANES) a very detailed mapping of temperature induced changes in distribution of elements and in the chemical form could be obtained. With a focus on Cr chemical states mapping in the project, the nano-XANES is pinpointed as the most efficient way to proceed and is available at the NanoScopium beamline of SOLEIL, France (25 nm spatial resolution at the energies required). The measurements can be complemented by bulk analysis by EXAFS (Extended X-ray Absorption Fine structure), which is available at the Balder beamline of MAXIV.

THE RESULTS AND EXPECTED IMPACT

With the increased understanding of the thermal degradation process, we will know how best to prevent it. With a higher thermal stability, the coating will be ready for commercialization and integration in Absolicon's solar collectors, increasing their competitiveness against fossil fuels.

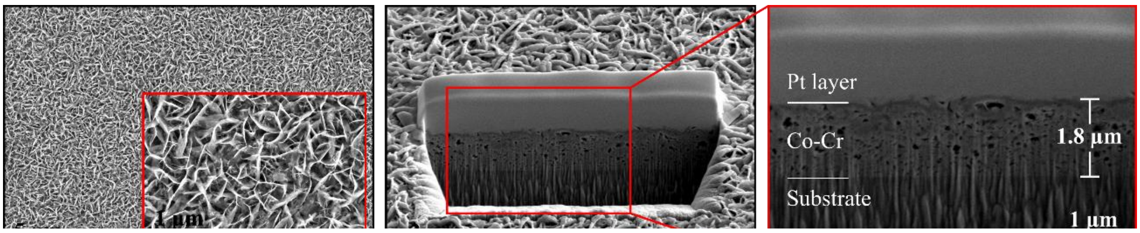

Figure 1. *The morphology, porosity and thickness give the Cr-Co coating its excellent optical properties.*

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