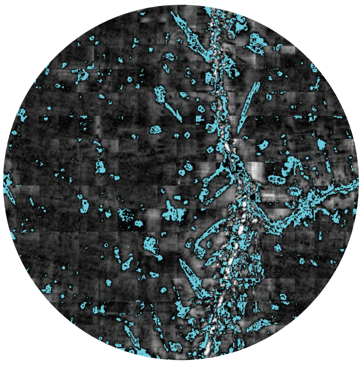
surfscan

NANODYNAMICS

Measuring the deterioration of steel in high temperature boilers

The surfscan helps determine the lifetime of critical boiler components by providing unmatched spatial resolution over mm^2 regions



The Problem:

The process by which steel and other metals harden and become brittle with exposure to high temperatures is significant for many industries because it defines the lifetime and maintenance schedules of critical components/equipment.

A major European energy supplier approached the Interface Analysis Centre (IAC) to try to understand how embrittlement occurs in their high-temperature boilers.

The IAC used a nano-indenter to produce low resolution hardness data which showed the process began on the exposed outer surface, but was not able to resolve how it affected individual steel grains or grain boundaries. Higher resolution data was required in order to fully understand and thus appropriately address the deterioration process.

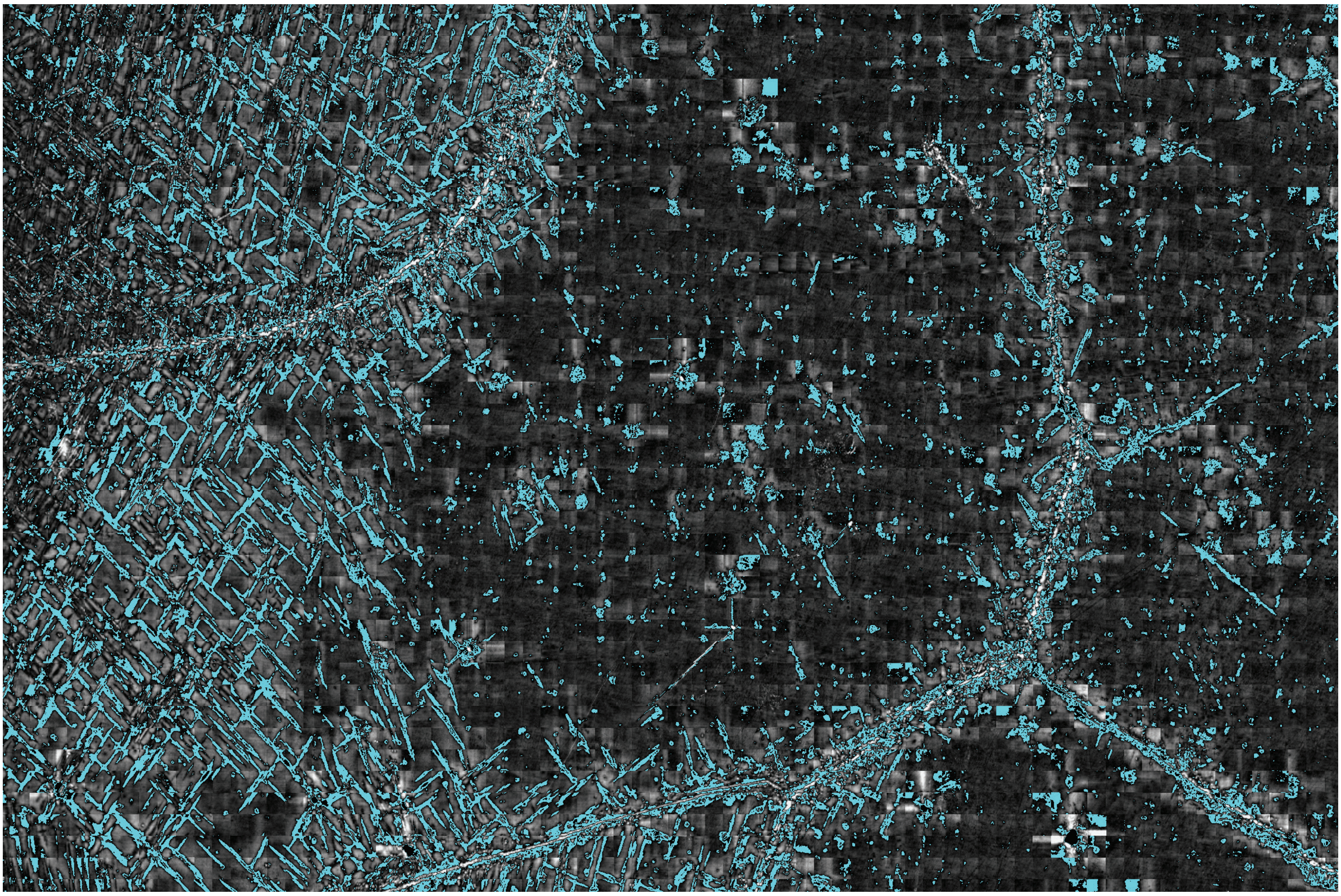
Our Solution:

The IAC wished to see if the surfscan could provide more detailed images of the steel they had been working with. The samples were cut as a cross section from the outer to the inner surface and taken from boiler components that had seen 18,000+ hours of operation at high temperatures. The surfscan produced a set of nanometre resolution height maps that covered the area from the outer edge of the steel to 1 mm in depth.

The samples were also investigated with alternative nanoscale imaging techniques including SEM. The surfscan was the only solution that detected these nanoscale carbon inclusions so deep into the metal and the unique large area capabilities of the instrument meant that a complete picture of the inclusions at the skin of a boiler could be gathered in a single scan cycle.

These images revealed that in addition to the high degree of carbon inclusions expected at the outer surface of the steel, a large amount of carbon had penetrated deeper into the bulk of the steel (see figure) by following the steel grain boundaries.

This was an unexpected and exceedingly valuable discover that has resulted in a change of focus for this strand of research. This information will also contribute towards new diagnostic maintenance tests, highlighting the regions within the steel which are at greatest risk and therefore give the earliest warning signs of component degradation.



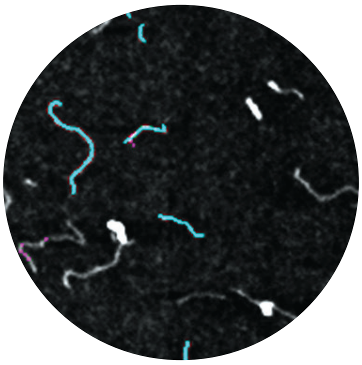
This false-colour 300 x 75 µm image of the steel surface highlights in blue the regions where carbon has penetrated the metal and reacted to form hard and brittle carbide inclusions. It is clear from this image that the exposed outer edge of the steel (left hand side) forms dense carbide inclusions, however, it was surprising to note how far into the bulk metal the carbide inclusions were able to penetrate by using the grain boundaries as pathways.

NANODYNAMICS

surfscan

Measuring the gene expression of single cells

Researchers at VCU and UCLA benefit from the surfscan's accuracy and sensitivity for the rapid measurement of a demanding sample: DNA from a single cell



The Problem:

A major challenge facing next generation gene sequencing is to develop techniques and instruments to measure the gene expression from single cells. These would yield new insights into variations within a cell population and provide more sensitive methods for detecting rare diseases and cancerous cells.

Researchers at VCU and UCLA are developing an innovative approach to single cell sequencing by analysing individual DNA molecules (identifying length and chemical markers) with an atomic force microscope (AFM). This approach sidesteps the need for time-consuming sample amplification steps and requires no expensive fluorescent labelling of samples.

Currently, they use commercial AFMs to obtain the necessary spatial resolution to identify each individual molecule. However, to measure the hundreds of thousands of molecules present within a single cell would take an AFM many days or even weeks of continuous imaging. This limitation is preventing their technique from undergoing the rigorous testing and repeat measurements necessary for validation and acceptance as a viable method for single cell genomics.

Our Solution:

We were approached to see whether the surfscan was capable of providing a practical solution to imaging large numbers of molecules with nanometre resolution, and thus help them advance the validation of their technique. We imaged a set of calibration samples and analysed the results to confirm the known identities of the DNA strands.

For a 50 x 50 µm region of DNA deposited on mica with a 2 x 2 nm pixel size, our device generated an image in just 10 minutes; the equivalent image from a commercial AFM had taken over 33 hours (200 times longer).

The increased sample throughput enabled them to determine the length distribution of the DNA with much greater statistical confidence, validating the technique for the first time. The surfscan is now integral to this group's continuing research in this area.

NANODYNAMICS

The image depicts one 6 x 4 μm area of a 50 x 50 μm image taken by the device. It shows the DNA and, with one of our automated data-analysis scripts, also shows how each DNA strand is located and then measured.