Steel Analysis
Advanced solutions from the macroscale to the nanoscale

Scrap Sorting
Inclusions
Liberation
Phases
Microstructures
Precipitates
Analysis from the ore to the product

It's essential that quality is controlled at all stages of the steel making process including:

- Ore exploration and mine mapping
- Iron ore liberation analysis
- Coke cleanliness analysis
- Scrap metal sorting and positive material identification
- Hot metal analysis
- Cleanliness: inclusions and trace element analysis
- Grain and texture analysis of the rolled product
- Deformation analysis
- Weld analysis

Ore and scrap metal analysis
- Analyse the mineral content of rocks and map their distribution in the field
- Characterise ore samples for potential metal recovery and process yield
- Identify iron-rich scrap and in the yard

Steel pre-production
- Identify and quantify impurities in the ore to avoid problems in the smelting process
- Determine coal mineralogy
- Analyse coke cleanliness at the microscopic level to prevent contaminants entering the mix

Steel production
- Assess the global constitution of the mix before pouring

Steel microanalysis
- Automated analysis of a sample inside an SEM provides fast and highly accurate characterisation:
  - Impurities and precipitates: identify the presence and distribution of trace elements and phases both qualitatively and quantitatively
  - Cleanliness: identify the number, shape and composition of inclusions and classify them to international standards
  - Grains: identify size, orientations and boundary conditions for strength and fatigue studies

Advanced research
- 3D analysis of welds and deformed structures
  - Element / phase analysis using a TEM for the ultimate in spatial resolution
  - Nanoscale measurement of magnetic, mechanical, and electrical properties

Unrivalled capability ‘off-the-shelf’

Unlike locked-in instruments from other vendors, our systems deliver truly state-of-the-art performance and can be quickly turned to other analysis applications as the needs arise.

Global support, locally delivered

Our solutions are supported by a global service operation that provides installation, training, maintenance and spare parts using a layered contract approach that will suit any customer needs.

The analysis tools you need. The global support you want.
Steel Microanalysis

Detecting impurities, mapping precipitates

...characterising inclusions and coatings

High speed location of inclusions
Accurate measurement of composition at the highest speeds at the micro- and nano-scale
Real-time classification by composition and morphology
Reporting to a range of international standards
Relocation of inclusions for further investigation

Steel cleanliness analysis at the microscale

Steel inclusions are found throughout steels and their shape and composition can have a range of negative effects. Inclusion analysis software automatically locates and analyses inclusions, classifying and reporting results to a choice of international standards.

Characterisation at the nanoscale

The required performance of steels is constantly becoming more demanding and a full understanding of even the smallest inclusions is now critical.

X-Max® large area silicon drift detectors combined with AZtec software record the internal details of inclusions at the sub-micron scale without compromising on speed.

Aluminium & titanium oxides form the core of inclusions with mechanically weaker phases enclosing them. AZtec mapping exposes the internal variations that define inclusion behaviour.

High performance feature detection, analysis and classification

Oxford Instruments’ X-Max® range of large area SDDs, provides the most sensitive EDS analysis on the market.

Ternary map showing inclusions compositions plotted against liquidus phases.
Trace element analysis

During steel production it is important to monitor the presence of trace elements such as sulfur and phosphorus to maintain a consistent quality and strength. However, these are often only present in trace quantities (<1000 ppm). The high precision and accuracy of the measurements needed to analyse such small quantities requires excellent spectral resolution. Oxford Instruments’ Wave is the only fully focusing WDS spectrometer available on the SEM. Using the same technologies as EPMA, it provides precise, highly accurate non-destructive analysis.

Grain size and phase distribution

Advanced image analysis measures grain sizes in Steel similar to optical microscopy methods but benefiting from the higher magnification available in the SEM. Image acquisition, processing and stage movements are automated so that large areas of the sample can be analysed unattended.

Stainless Steel 415 sample. Over 350 μm the sulfur concentration varies significantly, in comparison to phosphorus. Only WDS can measure ppm level variations.
Steel Microanalysis

Microstructural characterisation

- EBSD is an established technique for the microcharacterisation of steels
- Grain size determination
- Grain boundary type
- Texture measurements; including sheet, rolled or TRIP steels
- Phase determination: steel phases and inclusions
- Deformation analysis, e.g. steel rail

Grain size, orientation and boundary analysis

As the requirement for specialist steel grades have grown, it is increasingly important to fully characterise microstructure. Controlling microstructure and texture enables the development of stronger and lighter alloys.

EBSD - Electron Backscatter Diffraction - is a very powerful microstructural characterisation tool for the SEM. From a single data set it is possible to determine grain size, identify individual phases and determine preferred crystal orientation or texture.

Grain size is fundamental microstructure property of steel, ultimately determining mechanical properties. EBSD is a powerful alternative to traditional metallographic techniques in that it can distinguish twins and resolve much smaller grains.

EBSD can also characterise and quantify grain boundary types and misorientations within the steel. This enables the relationship between microstructure and material properties to be established and applied in material development.

A good example of the EBSD application is automotive steel. These typically advanced high strength steels (AHSS) have a multi-phase microstructure. The behaviour of the steel will be determined by the distribution and volume fraction of the individual phases, which are determined and visualised by EBSD.

Similarly, the crystallographic texture, determined by EBSD, is used to improve material performance.

In-situ EBSD

In-situ EBSD is performed in the chamber of the SEM. Microstructure changes are recorded in real time during heating or tensile experiments. This technique is increasingly used to monitor solid state events, including monitoring microstructure development, recrystallisation, phase transformations and phase relationships.

HAZ and weld metals

Welding processes may impact microstructure differently. EBSD is used to study the Heat Affected Zones (HAZ) and to determine the grain sizes and orientations which are developed.

Oxford Instruments’ AZtec software and the EBSD detector, Nordlys, provides high-speed and high-sensitivity data.
Advanced Microanalysis

- 3D analysis of grains
- 3D elemental analysis
- Characterising coating layers (composition and thickness)
- Nanoscale analysis in the Transmission Electron Microscope (TEM)

3D Analysis

Powerful 3D EBSD and EDS solutions can be combined with the milling capabilities of a FIB-SEM. This offers:

- 3D measurement for complete description of all grains, inclusions etc
- Advanced 3D characterisation of grain boundaries
- Morphological & crystallographic relationships between grains and phases

Coating Analysis

Oxford Instruments’ LayerProbe complements the elemental and phase information gained from conventional EDS analysis by also calculating the composition and thickness of nanoscale coatings.

TEM Analysis

High resolution TEM analysis is often used to interpret interactions at grain boundaries and the formation of precipitates, which may alter the physical properties of the alloys in question.

- The presence of niobium and titanium carbides is important in defining the microstructural and creep properties of high temperature steels. X-ray maps show the distribution of such precipitates.

Atomic Force Microscopy Analysis (AFM)

AFM is used to investigate the properties of steel at the level of single grains and grain boundaries. These nanoscale observations provide insight into the fundamental mechanisms of processes that ultimately affect macroscale performance.

- Measure electrical and magnetic properties. These vary with the manufacturing process and postmanufacturing treatment. Fatigue induced by processing and wear also affect them.
- Observe nanoscale corrosion and oxidation processes – users can image under liquid and at varying temperatures
- Assess materials properties (Young’s modulus) in the original manufactured material or post-processing/ wear-induced

Magnetic force microscopy distinguishes ferritic domains (orange) from the surrounding austenitic phase in a duplex stainless steel. Original 20 μm image courtesy of L. Belova, KTH Royal Institute of Technology.

www.oxinst.com/EBSD

www.oxinst.com/AFM
Handheld XRF analysers for instant on-site analysis

With the X-MET7000 Series analysers you can achieve laboratory grade analysis from raw materials to refined products, and just about everything in between in a matter of seconds.

- Minimise the need for expensive and time-consuming laboratory analyses
- Fit for purpose, the rugged design withstands the harshest environments
- Maximise mine-mapping efficiency: GPS/GIS integration to combine location data with analysis results for mine mapping

Powerful, automated Mineral Liberation Analysis

We provide a powerful, automated Mineral Liberation Analysis solution that enables ore characterisation, provides vital data on metal recovery and enables process yield characterisation using a multipurpose SEM.

Exploiting the performance of Oxford Instruments’ large area SDDs (X-Max™), it provides accurate classification of minerals at speeds easily comparable to dedicated systems – but with the flexibility to perform other investigations as required.
Closing the steel process loop

Grade and Trade
Rugged handheld XRF and LIBS analysers for rapid scrap sorting and analysis
- mPulse: the first handheld LIBS analyser
  - Sort metal alloys in just one second
  - Test all sample forms and sizes, including shavings, turnings, etc.
- X-MET 7000 Series:
  - Rapid and accurate alloy analysis
  - Determine valuable metals and penalty elements
  - Flexible and powerful data reporting capabilities
  - Mobile and Stationary Optical Emission Spectroscopy (OES) products
- OES is ideal for low detection limits and light elements and is essential for carbon analysis

Our range includes mobile OES when you need to take the analysis to the sample, and stationary OES when the sample can be taken to the analysis
- Perfect for higher precision and greater accuracy on special alloys

Metal analysis
Metal analysis with optical emission spectrometers (OES) is necessary throughout the quality control process of steel production, and industries using steel products. OES delivers precise analysis in seconds for all steel elements.
- Melt analysis and process control during steel production (steel mills, foundries) ensure that the production composition is as specified
- Automated pass-fail testing used across the complete production cycle. OES delivers ‘100% testing’ in steel bar, rod and tube production
- We also provide mobile OES and automated inline OES solutions to suit customer QA/QC requirements
- Positive Material Identification is used to determine the specified steel grade in metal processing in many industries. XRF and OES are used where there is high demand for higher precision and accuracy

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Global Customer Support

Accredited, experienced, responsive, dedicated

Oxford Instruments recognises that your success requires not just only world-class products, but also world-class service and support. Our global service team is renowned for delivering outstanding service to customers and microscope vendors:

- Hands-on and theory classroom training
- On-site training tailored to your specific needs
- Web-based courses and training videos
- Consultancy and application support
- Multi-layered maintenance and service contracts

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