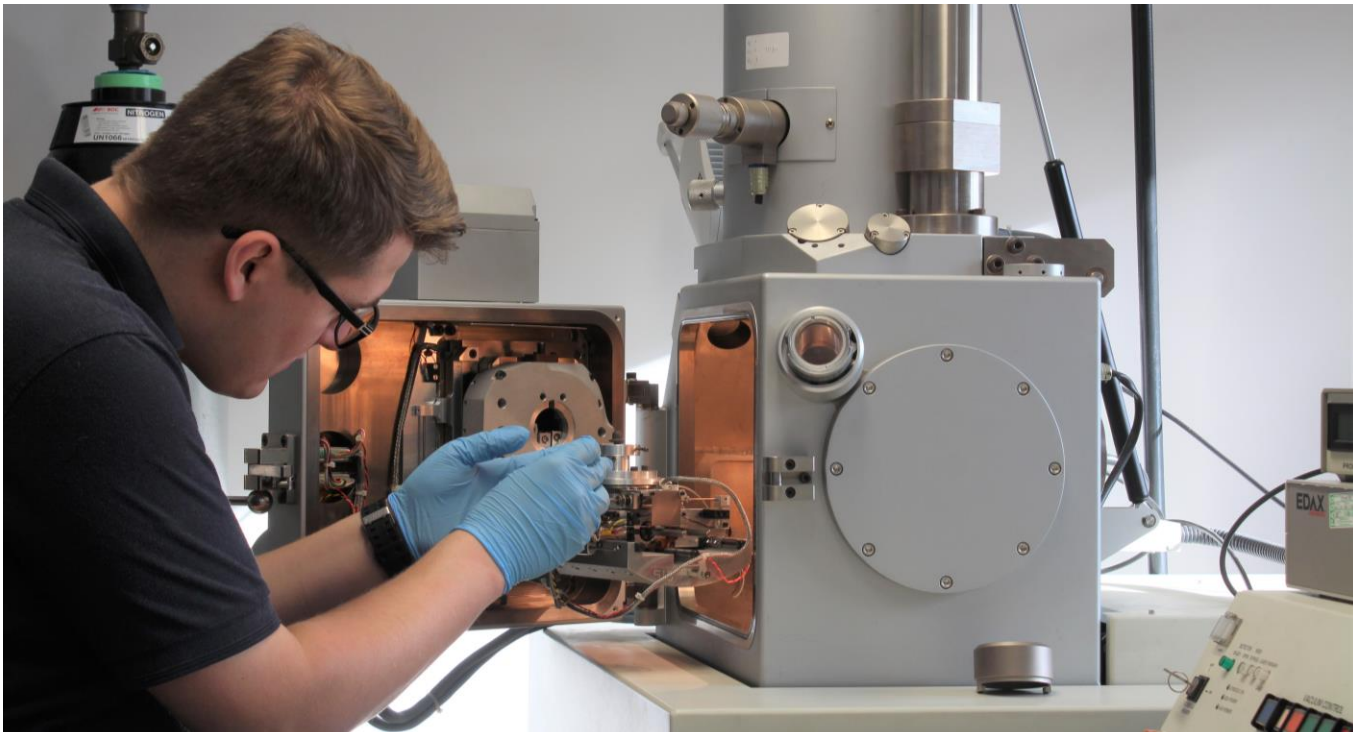
SCANNING ELECTRON MICROSCOPY

The Scanning Electron Microscope (SEM) used at SureScreen Scientifics is an instrument that provides high resolution images of samples up to a usable magnification of nominally 50,000 times, which is far greater than traditional optical microscopy. The SEM provides morphological information by displaying an image of the sample surface using the main detector known as the Secondary Electron Detector (SED). The SED provides a high resolution and high depth of field image of the sample and is therefore ideal for examination of samples with varying morphology such as the fracture faces of engineering components.

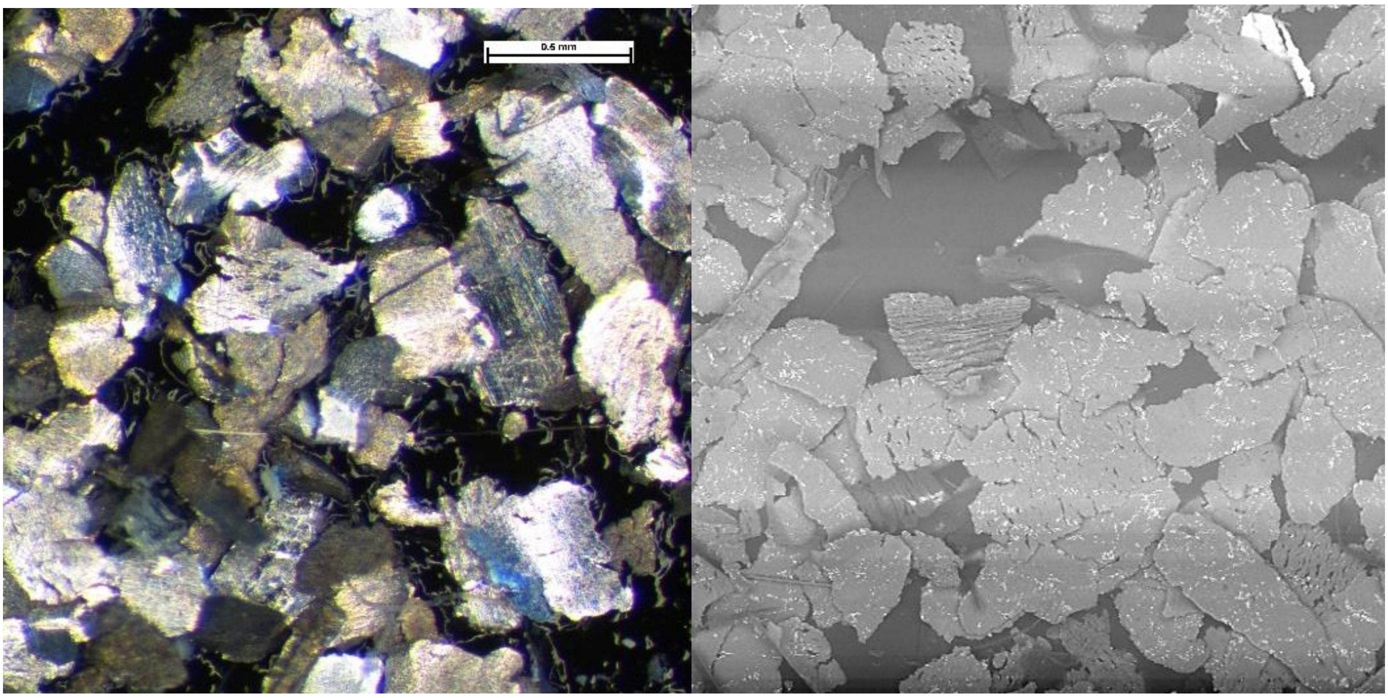
The SEM also has an Energy Dispersive X-ray (EDX) attachment that provides a semi-quantitative elemental breakdown of the areas being viewed. The EDX can be used for spot analysis of a specific point, an area analysis or even by elemental mapping to see which elements are present and where. More information on the EDX facility is included in a separate white paper.



Careful preparation and handling of samples is paramount to achieving a high-resolution image. Any residual particles on the surface of a sample can become electrically charged and show as a dark halo on the image. To combat this, samples may be ultrasonically cleaned in solvent and handled with gloved hands in a clean environment before being mounted in the instrument.

Samples mounted in the SEM must be conductive so that a stable image can be obtained. If a sample is not naturally conductive it can be coated in a thin layer of conductive material (typically gold or carbon), meaning that non-conductive or organic materials can still be viewed. This layer is typically applied using a sputter coater to a depth of 5-10nm. The depth is so shallow that the majority of the fine surface details are retained, and the coating still allows for chemical analysis of the material beneath it by the EDX attachment.

As well as high magnifications, the instrument can display variations in the elemental composition of the areas being viewed by using the Backscattered Electron (BSE) detector), shown in grey scale. This means phases in crystallographic materials or surface contaminants etc. can be seen and later identified.



Debris gathered from a race car gearbox filter comparing an optical image (left) and a BSE image (right) from a different area of debris. The BSE image can be seen to show variation in the chemical composition of the particles. The brighter particle (top right corner) is iron and the grey flake-like particles (the majority) are magnesium alloy. The BSE image also shows the different phases within the magnesium alloy as seen by lightly coloured spots; these areas are consistent with a silicon phase. Images taken at X40.

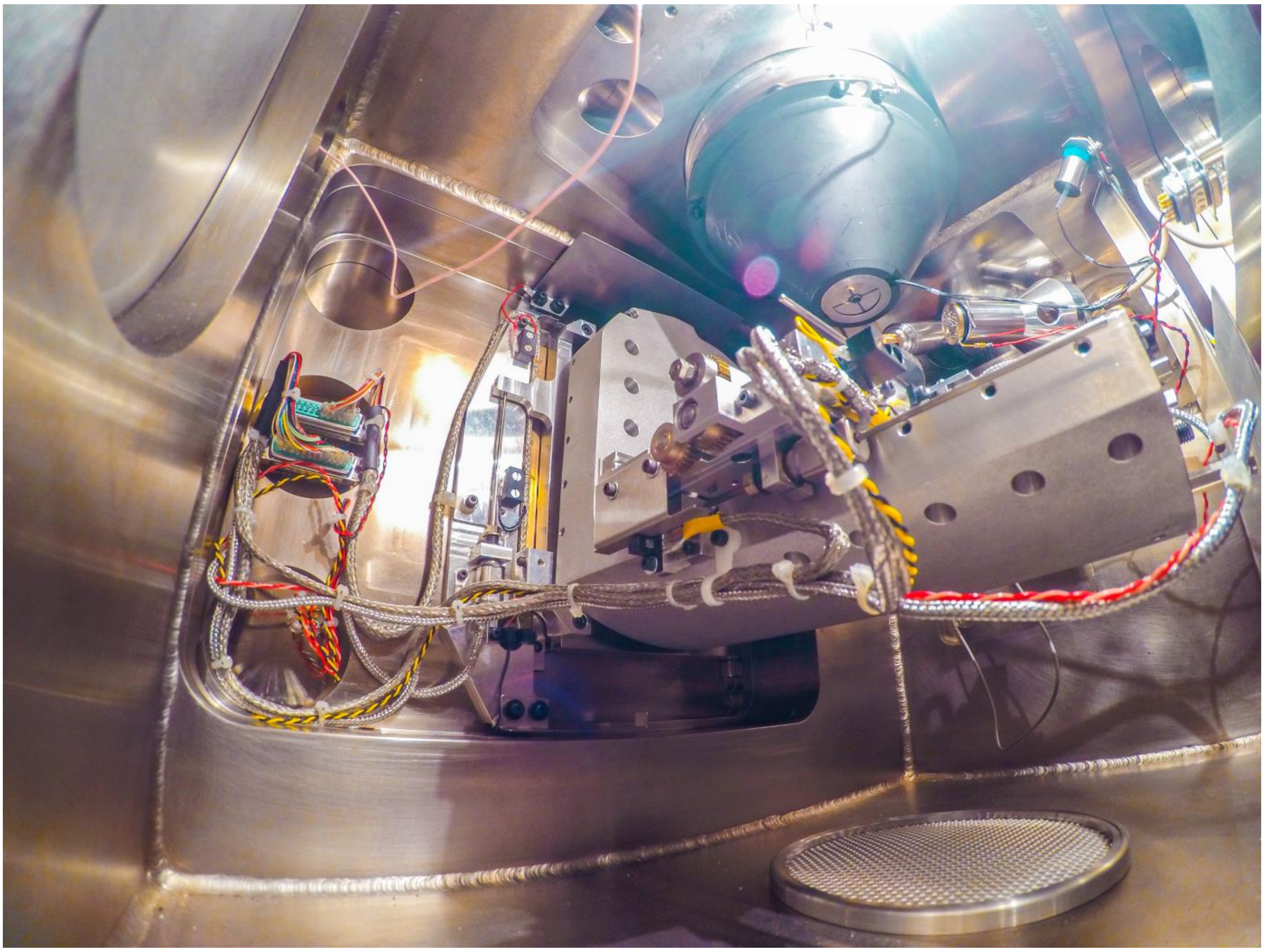
The SEM has a wide scope of uses within an engineering laboratory and particularly at SureScreen Scientifics where it is vital for use in identifying failure mechanisms when small variations in surface topography can define a certain failure mechanism.

Further uses for the SEM include:

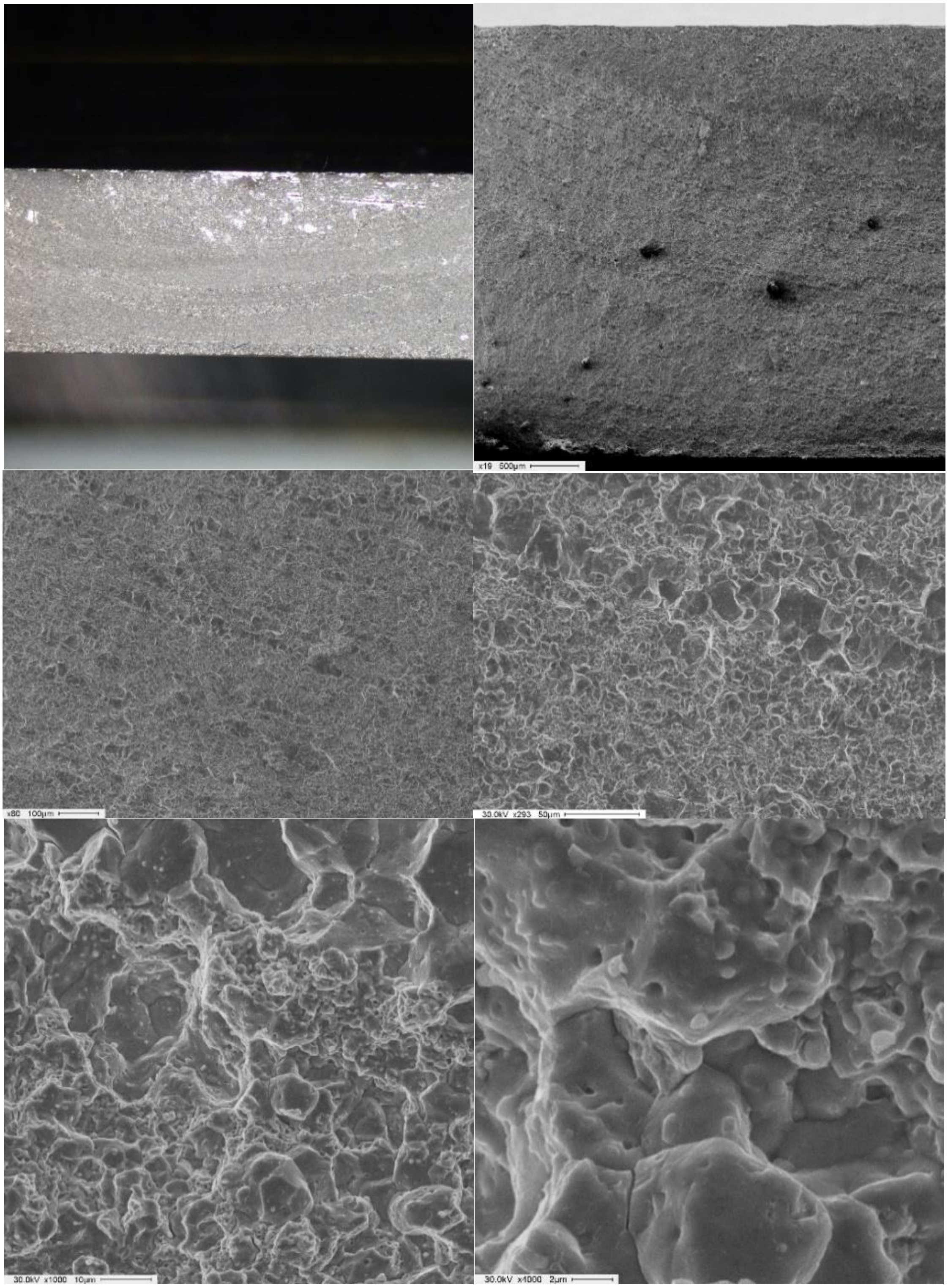
- Wear/contact mechanisms — i.e. Smearing, battering, RCF, fretting
- Surface finish — i.e. roughness, profile
- Particle Examination — i.e. debris or contamination
- Coatings — i.e. Surface finish, cracking, spalling

About…

The first commercial SEM was developed by British professor Sir Charles Oatley in 1965. Since then the fundamentals of scanning electron microscopy have remained relatively the same, though the user interface, accessibility and quality of images have been vastly improved over the years. A scanning electron microscope works by scanning a rectangular raster of focused electrons, which are emitted from a filament, across the surface of a specimen.



Inside the vacuum chamber of the scanning electron microscope



Macroscopic examination of this fracture surface suggested that the failure had occurred due to fatigue, as shown by the beach-like markings radiating from the surface. An SEM examination showed this not to be the case, and that the markings were associated with variations in the microstructural grain size generated during forging, creating a banded brittle fracture surface. Images taken are from between X6 and X4000.

Forensic Scientists and Consultant Engineers
SureScreen Scientifics Ltd, Morley Retreat, Church Lane, Morley, Derbyshire, DE7 6DE, UK
Tel: +44 (0)1332 292003 Email: scientifics@surescreen.com
Company Registration No. 08950940