# SEM: Points for discussion

## What is ESEM?

The term ESEM (or Environmental SEM) is used to denote that a specific environment (atmosphere) is used. Can be used to image non-conductive samples.

[1] Y. I. Vega, Introduction to Electron Microscopy: Scanning Electron Microscopy and EDS: Energy Dispersive X-ray Spectroscopy, in: M5052 Charact. Mater. Nanomater. - Grad. Progr. Nanotechnol., N.L. Monterrey, 2015.

## What is the difference between image acquisition in ESEM and SEM?

ESEM can produce images of wet samples or contained in low vacuum or gas. This technique facilitates the characterization of biological samples that are unstable in the high vacuum of typical electron microscopes.

[2] What are the main differences between an SEM, an ESEM, an SEM-FIB and an (S)TEM?, (n.d.). https://www.horiba.com/en\_en/cathodoluminescence-spectroscopy-sem-esem-sem-fib-stem/ (accessed 7 May 2020).

## Describe what is EDS

Energy Dispersive (X-ray) Spectroscopy or EDX is an accessory for SEM and TEM to measure X-rays. Due to quantization of energy levels, the X-ray photon energies are characteristic of the element and the energy levels involved. However, EDS does not provide chemical information. X-rays are generated when electrons lose energy by interacting with positive nucleus (through the emission of photons).

[1] Y. I. Vega, Introduction to Electron Microscopy: Scanning Electron Microscopy and EDS: Energy Dispersive X-ray Spectroscopy, in: M5052 Charact. Mater. Nanomater. - Grad. Progr. Nanotechnol., N.L. Monterrey, 2015.

ESEM is especially useful for non-metallic, uncoated, non-conductive and biological materials. The presence of gas, mainly Argon, around a sample permits to work with pressure greater than 500 Pa compared to conventional SEM requirements samples under vacuum about 103 to 104 Pa.

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## How EDS is used in combination with electron microscopy?

EDS is implemented when there is no information about the expected composition of the sample, a spectrum can be acquired instead from the whole observed area under SEM. The spectrum will show characteristic X-rays of all elements under the studied area, which allows the identification of concentration gradients and different phases.

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## What are the applications of EDS?

* Detection of chemical residues at the nanogram level
* Study of morphology of particles and elemental composition

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