

## **Adaptive optics and where to find them. A guide to new ideas and application to material science**

V.Grillo

Institute of Nanoscience S3 Via campi 213/a 41125 Modena Italy

Electron microscopy has received a twist when vortex beam has been introduced as many more forms of electron beam could be functionally added to the possibilities.

Suddenly a whole world of possibilities of different measurement and probe was open. The revolution was started by hologram but more idea took over and the most innovative thing are now probably the phasing devices based on MEMS technology.

Our MEMS, developed in collaboration with Thermofisher, allow up to 8 pin to connect a special holder to the MEMS and drive different electrodes located close to the electron beam that modify its shape.

The most spectacular application of this idea is the so called "OAM sorter" where two MEMS located strategically along the TEM column, can be used to drive a conformal transformation of the electron beam able to measure the orbital angular momentum.

Having a new fundamental measured quantity in the electron microscopy means being able to new sample properties. In the case of OAM we can measure magnetic dichroism, symmetry of states and samples and select different multiple transitions in EELS.

The success of the OAM sorter is also due to the use of neural network that we developed and that allows delicate and semi-automatic alignment operation comparable to those of an aberration corrector.

The flexibility of MEMS and the computational power of the neural network can be further used in many other forms to create what we could call "adaptive optics".

A very important example is the revolution we are introducing with the "computational ghost imaging" that allows us to go beyond the simple probe scanning. A series of custom probe shape can be created to measure the sample, based on the partial results the next probe shapes can be optimized to improve the imaging with the aim of reducing the dose on the sample.

In fact the next revolution will be in the field of cryomicroscopy where dose considerations are very important. This will guide the audience quickly through all of this and more.

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