Electron and ion optics behind TESCAN instruments

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Within more than twenty years, TESCAN Brno has grown from a small company of several people into an enterprise with three hundred employees. TESCAN ORSAY holding established in 2013 by merging with Orsay Physics, France, produces both scanning electron microscopes and focused ion beam systems.

The SEMs involve the VEGA with thermoemission (W/LaB6) electron gun and a range of FE-SEMs equipped with a Schottky Field Emission Gun (MIRA and MAIA), the latter being an ultra-high resolution FE-SEM with an immersion lens. These SEMs with added gallium FIB and Gas Injection System (GIS), LYRA and GAIA, can be integrated with a number of 3rd party devices, e.g. the Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS), Scanning Probe Microscope (SPM), manipulators, and analyzers, making them a truly multifunctional laboratory of its own (see Fig. 1). The unique FERA and XEIA Plasma FIB-SEMs are using focused beam of xenon ions (instead of gallium) to increase the sputtering rate up to 50 times. All FE-SEMs can be equipped with a cathode lens (Beam Deceleration Mode) with optimized resolution for low voltage applications [1].

Thorough analysis of the lenses and deflectors is a prerequisite for a correctly functioning microscope. The fields of lenses and deflectors and their optical properties are computed with high accuracy in EOD program [2]. These fields are then used in the In-Flight Beam Tracing™ software module of the microscope to adjust the lens system for optimum performance for any beam energy or beam current, displaying mode, and working distance, even if the beam is decelerated in the cathode lens before it arrives on the sample. The computations in SEM control software are performed in real time for all combinations of overlapping electrostatic and magnetic fields. This provides high accuracy for all conditions, including the cases where the sample is manipulated within any field. The In-Flight Beam Tracing is performed also in the case of focused ion beams.

Electron optics with the additional intermediate lens (IML) just above the objective lens (see Fig. 2) allows various displaying modes, for example to increase the depth of field by decreasing the beam aperture, compared to the standard resolution mode using the objective lens alone, or to operate the IML alone to enlarge the field of view. Even further decrease of magnification allows the so called wide field mode in VEGA, MIRA and LYRA SEMs. Fine adjustment of pivot point of deflectors and dynamical correction of deflection aberrations are important to guarantee distortion-free image. The same requirements hold also for the channeling mode.

A more precise analysis of spot profile to get SEM resolution that includes the effects of spherical and chromatic aberrations as well as diffraction effects has recently been implemented as a plug-in module of EOD [3].

The presentation will give an overview of approaches to charged particle optical calculations, various displaying modes, and extended level of multi technique integration that enrich microscope functions to a new generation of imaging and analytical tool.

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[2] J. Zlámal and B. Lencová, Nucl. Instr. Meth. In Phys. Res. A645 (2011) 278-282
[3] J. Kološová et al, Abstracts CPO9, Brno 2014, 25
[4] J. Jiruše et al, J. Vac. Sci. Technol. B32 (2014) 06FC03

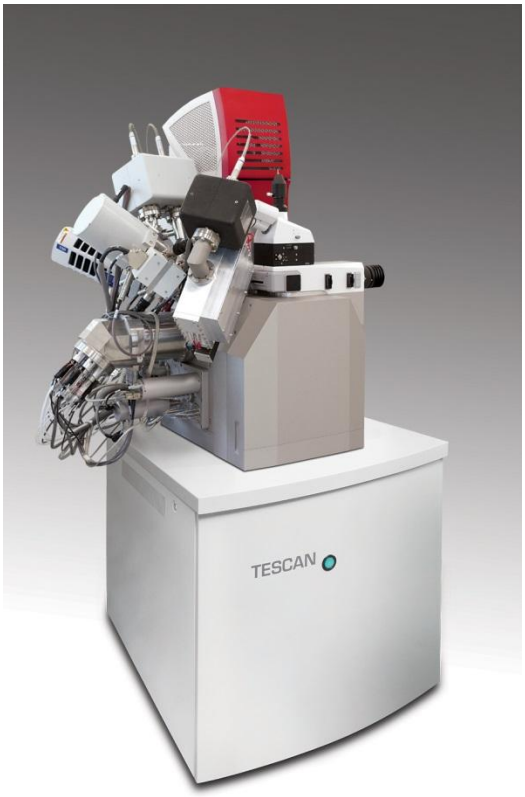

Fig. 1. GAIA uses immersion optics, here it is equipped with EDX, GIS, Ga FIB, and TOF-SIMS (from left to right); above the door on the right there is a confocal Raman microscope [4].

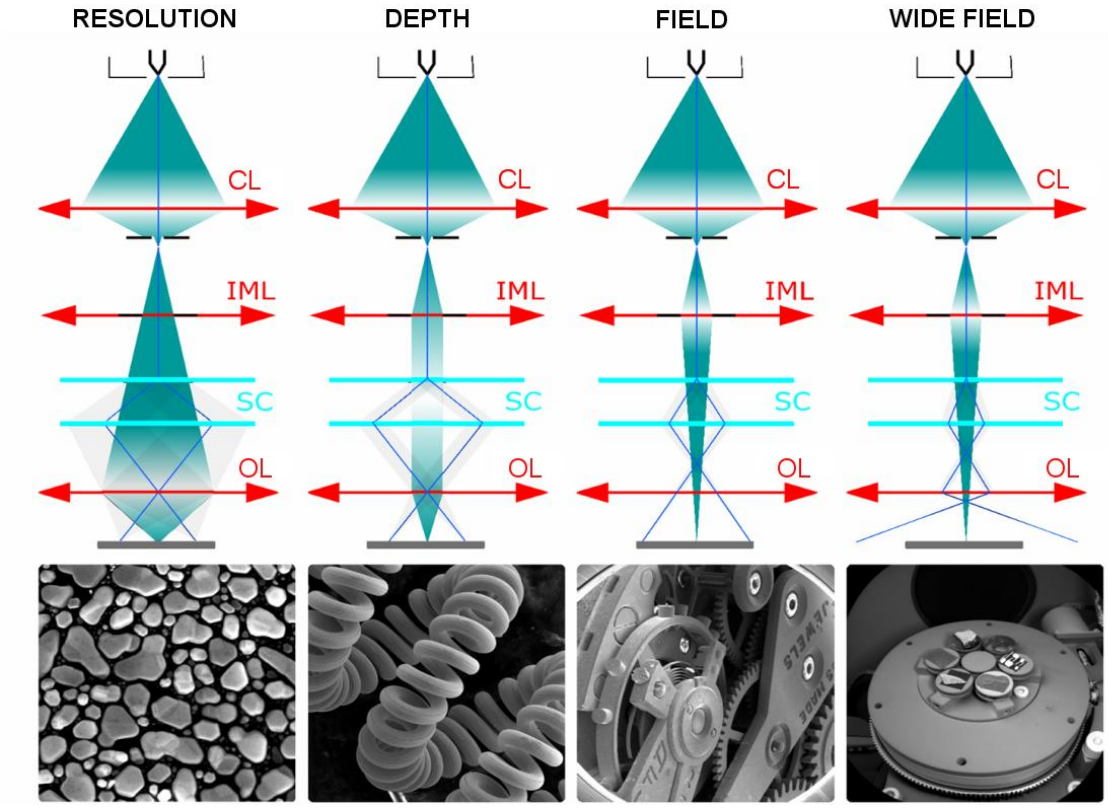

Fig. 2. Displaying modes used in TESCAN SEMs. CL denotes condenser lens (there are two condenser lenses for thermoemission tungsten or LaB6 SEM), IML intermediate lens, OL objective lens, SC scanning coils. The beam focusing as well as scanning are schematically shown.