SESAM and SATEM – going to the limits what's physically-technically feasible

LEO develops two High-End Transmissions Electronen Microscopes, which aim to reach the limits that are physically-technically feasible. These instruments are individual development projects for 2 renowned German Research Labs, funding is provided by German Research Society and Max-Planck-Society.

The required performance parameters for the **SESAM** (Sub-Electronenvolt-Sub-Ångstrom-Microscope) and the **SATEM** (Sub-Ångstrom-TEM) attain worldwide attention inside the TEM-community, as application-fields presently out of reach will become approachable.

The extraordinarily sophisticated specifications triggered substantial innovations in LEO-TEM-Technology: for example development of a new TEM-column with increased diameter, in order to obtain the required mechanical stability and to gain space for further improvements of magnetic lenses and other electron-optical components. The newly constructed 300 mm-column as well as the new Field Emission Gun (FEG) and the corrected 90°-Omega Filter consequently will be integrated into the innovative future Libra 200kV-Series.

Furthermore some new components will be integrated at the present exclusively into both these instruments:

- For both machines the FEG will be equipped with a **Monochromator**. This optical component acts as an energy filter for the electrons emitted by the source and enables to reduce the width of the electron energy distribution in the beam from the FEG-inherent value of 0,7 eV down to values below 0,2 eV. Due to his compact design the monochromator fits completely into the FEG-housing and in no way influences the standard TEM-performance when the filterfunction is switched off. With monochromatized illumination of the sample under investigation, EELS-Analytics (Electron-Energy-Loss-Spectroscopy) with a resolution below 0,2 eV become possible. Moreover such a monochromatic electron-beam is a prerequisite for increasing the resolution of an electron microscope in imaging- or STEM-mode to values better than 1 Ångstrom (0,1 nm) by incorporation of electron-optical aberration-correctors.
- The SESAM-instrument targets at *highest performance for energyfiltering-applications* (resolution better than 0,2 eV, very large transmitted angles for filtered diffraction experiments) and will therefore be equipped with the so-called **Mandoline-Filter**. The Mandoline incorporates a total of 9 magnetic multipole-elements, that will provide complete correctability for all aberrations up to the 3. order. This most sophisticated imaging energyfilter ever been realized by now offers unrivaled performance capabilities regarding dispersion (6,2 µm/eV) and transmissivity.
- The SATEM-instrument targets at *highest resolution in the imaging-mode*. Therefore an electron-optical correction-module will be integrated, compensating the spherical aberration (coefficent Cs) of the objective-lens and thus improving the resolution limit to below 0,1 nm. The so-called **Cs-corrector** is a complicated optical setup consisting in 2 hexapol-lenses and several transfer-lenses and is adapted into the column directly *beneath* our newly developed objective-lens. Furthermore the SATEM will be equipped with the new corrected 90°-Omega Filter - the standard Filter for the Libra 200kV-series – and therefore also here highly sophisticated energy-filtered TEM-applications are possible.
- The integration of such a corrector *above* the objective-module is another very promising option. With this combination, an electron-spot with a size in the sub-Ångstrom-regime can be formed on the sample and therefore atomically resolving Scanning-Transmission-(STEM-) operation becomes possible. The first implementation of such setup will be realized until 2004 for the **Caesar**-project.
- The optical performance power of SESAM and SATEM can in practice only be achieved, if extremely stable operation conditions are provided for the electron-optical column. Besides an optimized installation in an extraordinarily disturbance-free laboratory, the sensitivity of the column against any transmission of external mechanical excitations – e.g. caused by floor vibrations or acoustics – has to be minimized. To achieve this, we have realized a new „**hanging-column concept**". The TEM-column is supported like a pendulum in a highly stable frame, which has been optimized for maximum stiffness while providing the necessary accessibility to the column. This innovative concept leads to a completely new appearance for the SESAM and the SATEM and we are convinced that it will be trendsetting for future „State-of-the-Art" Transmission electron microscopes.

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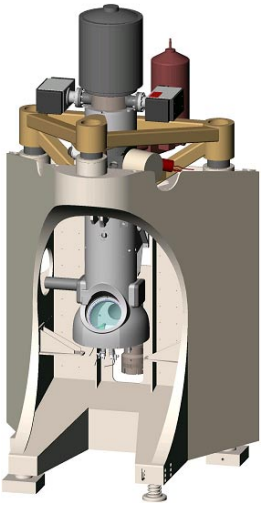

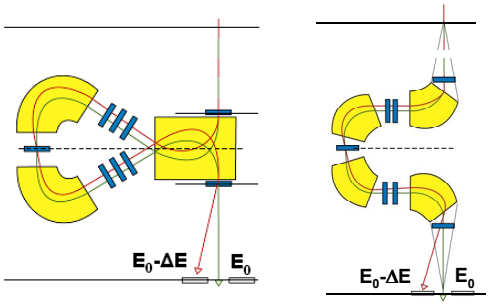

Schematic raypaths in the **Mandoline-** (left) and in the **corrected Omega-Filter** (right). Magnetic sectorfields (yellow) and positions of multipole-correctorelements (blue) are shown.

CAD-model of the **SESAM:** first realization of a pendulum-like „hanging-column concept" in an optimized and highly stable support frame.

The **SATEM** instrument:
start of electron-optical operation.