# Lab course: Low energy electron microscopy (LEEM)

**Do not carry out any action with the LEEM without confirmation by the supervisor! Vacuum valves are operated by the supervisor only!**

## 1 LEEM setup

The low energy electron microscope used in this lab course is shown schematically in Figure 1.

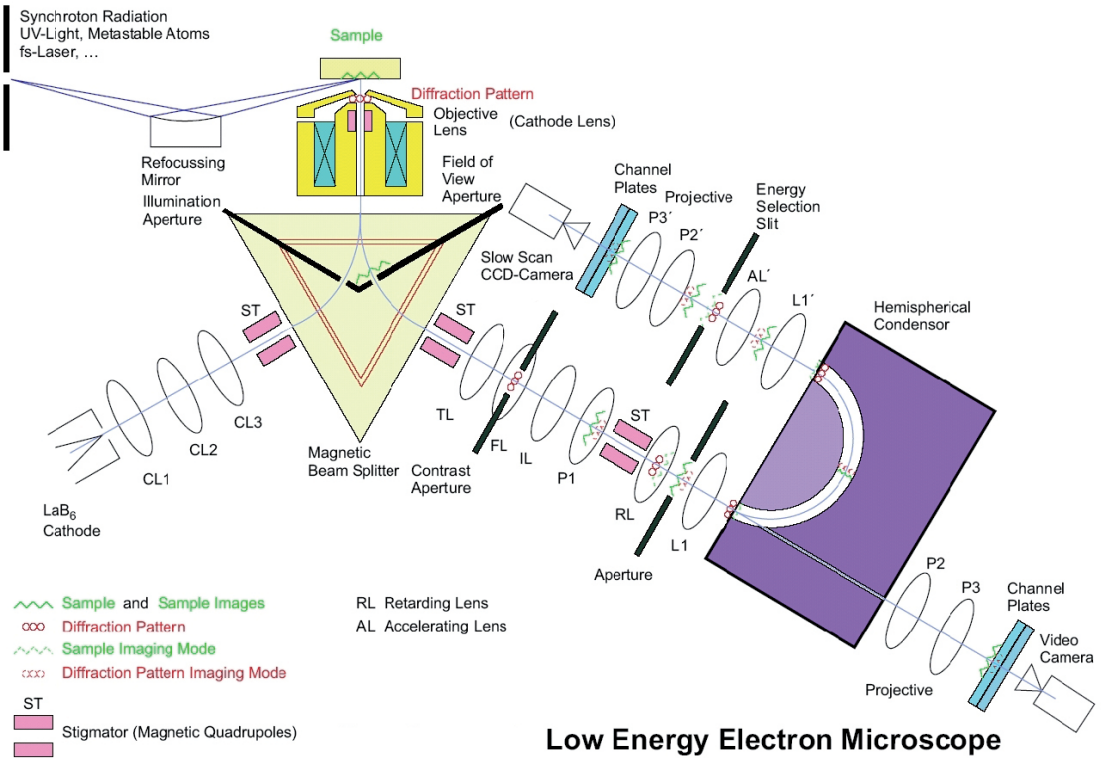


Figure 1: Schematic setup of the LEEM

In addition to electron microscopy, the setup can also be used for low energy electron diffraction at µm-sized regions (=µLEED) and photoemission electron microscopy (=PEEM). In this course you will not use the hemispherical energy analyzer, but operate the microscope in an energy-integrating mode.

## 2 Materials

You will investigate a monolayer of *para*-sexiphenyl (*p*-6P) molecules adsorbed on a clean Ag(111) surface. The molecules have been thermally evaporated onto the cleaned surface of the silver crystal. The crystal surface was cleaned by argon sputtering and annealing in UHV. Figure 2 shows the arrangement of the top layer Ag atoms of a Ag(111) surface. The structural formula of *p*-6P is shown in Figure 3.

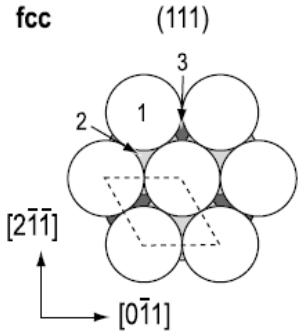


Figure 2: Arrangement of surface atoms of the Ag(111) surface

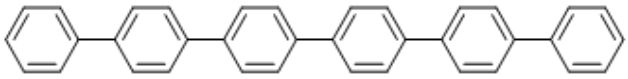

Figure 3: Structural formula of *p*-6P

# 3 Experimental tasks

1. Confirm that the LEEM instrument is aligned and familiarize yourself with the operation of the instrument.
2. Operate the LEEM in bright field mode. Optimize the LEEM parameters (electron energy, focusing) for a good contrast of step edges of the Ag(111) substrate.
3. Takes µLEED images from different surface regions with differently sized illumination apertures.
4. Create several dark field images from the same surface region that was imaged in task 2 using different LEED spots.

# 4 Data analysis and discussion

1. Analyze the µLEED pattern obtained from an individual domain to determine the surface lattice cell parameters of the *p*-6P monolayer.
   - Use the LEED spots of the Ag(111) substrate ($a_{\mathrm{fcc}} = 4.085\,\text{Å}$) as a scale for the images in reciprocal space.
   - Identify a set of *p*-6P LEED spots which forms a unit cell of the reciprocal surface lattice.
   - Determine the lattice constants and angles of the adsorbate lattice and calculate the matrix which describes the *p*-6P superstructure with respect to the Ag(111) substrate.
2. Explain why the LEED pattern obtained from a larger sample area differs from the µLEED image of a single *p*-6P domain.

3. Combine the dark field images into a single false color image which visualizes the distribution of the different $p$-6P domains on the surface.

4. Discuss how the local structure of the surface influences the arrangement of $p$-6P molecules.

    - Compare the composite dark field image with the a bright field image of the same surface area to find correlations between between substrate morphology and the arrangement of molecules.