

3.3. Experimental set-up

The experimental set-up of the polar MOKE spectrometer for ultra-high vacuum operation is presented schematically in Fig. 3.3. After preparation of the samples (see Chapter 4) in the deposition chamber of Prof. Keune's group their chemical purity, structure and magnetic properties are investigated by using Auger-Electron Spectroscopy (AES) and Conversion Electron Mössbauer Spectroscopy (CEMS), respectively. Furthermore, Reflection High Energy Electron Diffraction (RHEED) and Low Energy Electron Diffraction (LEED) systems are available to characterize the structure of epitaxial layers during preparation. Subsequently the samples are transferred into our sample chamber, where the samples are mounted on the sample holder of a manipulator by means of two orthogonal wobble sticks. Movement of the samples is achieved with a sample manipulator, which allows movement of the samples by 600 mm along the horizontal z-axis and into x and y directions perpendicular to the z-axis by ± 20 mm.

A basic pressure of about $3 \cdot 10^{-9}$ mbar is achieved in the sample chamber after heating 48 hours at temperature of 450 K (excluding the windows !). The system is equipped with an additional sample lock-chamber in order to study ex-situ samples. Thereby the pressure remains below $5 \cdot 10^{-7}$ mbar without heating the system.

The samples can be studied in a temperature range between 40 and 1000 K by means of a He evaporation gas-flow cryostat and a resistant heater. Controlling of the temperature is done through a PID controller (Oxford Instruments, ITC 4) with proper parameters within $\Delta T = \pm 0.1^\circ\text{K}$. The temperature is measured by two NiCr-Ni-thermocouples (Philips, Thermocoax, Type K). One of them is located at the He-evaporator and the other one close to sample.

The window consists of fused silica (Huntington, VPQ-FB-050-F2.12) with a thickness of 3.175 mm ($1/8''$) and a diameter of 12.5 mm ($1/2''$). It is sealed with a special lead alloy on a CF type 2 $1/8''$ flange. Birefringence in the center of the window can be neglected but is shown to increase close to the rim. It is strongly dependent on temperature and mechanical strain.

A xenon high-pressure lamp 150 W (Osram, XBO 150 W/S) is used as a light source, L (Fig. 3.2 and 3.3). The wavelength range used lies between 250 and 900 nm. The lower limit of wavelength (250 nm) is given by the spectral emission distribution of the lamp and the higher

limit (900 nm) by the detector (photomultiplier). The reflector is located at the backside of the lamp housing and collects that part of light, which passes a water filter. The water absorbs the intermediate infrared part of the Xe light, which otherwise gives rise to harmful warming of the optical fibre. The condensor focuses the light on a spherical lens with a diameter of 5 mm and a focal length of 3 mm. Subsequently the light is coupled into the optical gradient fibre with a core diameter of 0.4 mm. This light emerges from the fibre in front of the polarizer P and is parallelized by using a lens with a focal length of 40 mm. Thereby the end face of the fibre acts as a point-shaped light source. Undesirable spectral components at different wavelength ranges are faded out by a band pass filter (Schott, KG1) for the visible range, $400 \leq \lambda \leq 650$ nm, and by a cut-off filter (Schott, RG 630) for the near infrared range, $\lambda > 650$ nm. The parallelized light is polarized by a Glan-Thompson-air polarizing prism. The polarization plane lies under an angle $\alpha = \pi/4$ with respect to the x axis (see Fig. 3.2).

The linearly polarized light is modulated by an elasto-optic modulator (EOM) O (Hinds, PEM-90) with a modulation frequency of 50 kHz. The main axis of the modulator lies by $\pi/4$ rotated against the polarization plane. The Babinet-Soleil type compensator C controlled by a stepper motor is located behind the EOM. The compensator serves as $\lambda/4$ -plate for Kerr ellipticity measurements.

A lens L_1 with a focal length of 400 mm focuses the polarized and modulated light on the sample. The reflected light first passes the lens L_2 ($f = 300$ mm) and subsequently the analyzer A (Glan-Thompson-air polarizing prism). The analyzer is rotated by a computer-controlled step motor. The reflected light is coupled into the optical fiber F_2 by using a spherical lens and subsequently into a single grating monochromator G (Spex Doublemate) with a spectral bandpass $\Delta\lambda \sim 2$ nm before reaching the photomultiplier D (Hamamatsu R955) (working between 160 and 900 nm) located at the exit of G, which can be tuned in a wavelength range between 185 and 1200 nm. The direct combination of G and D suppresses the influence of surrounding light so that no measurable effect is detected even when switching on external light sources. The detected signal is amplified by a current preamplifier (Ithaco, Model 565), which ensures a linear amplifying factor of 10^3 at frequencies up to 100 kHz. Different Fourier components of the light intensity, I_ω and $I_{2\omega}$ corresponding to Kerr ellipticity and rotation, respectively, are detected by use of the two lock-in amplifiers A1 and A2 (EG & G Mod. 5202

and 128A), which get the reference signal from the EOM oscillator. Simultaneously the dc intensity I_0 is measured by the amplifier A_0 independently of both β and γ (see above).

All controlling tasks, stepper motors for compensator and analyzer, magnetic field strengths and monochromator, and calibration of Kerr rotation and ellipticity are performed by virtue of a self-made computer program [Ader93]. Details are found in the diploma thesis of S. Botermann [Bote92]. Resolutions and repeatabilities of $\delta\beta < 10^{-3}$ and $\delta\gamma < 10^{-5}$ are achieved with the help of computer controlled stepper motors.

Magnetic field strengths up to $|6.4|$ MA/m are achieved by using a superconducting solenoid with a warm bore of diameter 540 mm (American Magnetics Inc.). It is controlled by means of a bipolar control unit (Lake Shore, Control Unit 601) via a high current net (Lake Shore, Superconducting Magnetic Power Supply Model 612). The maximal field strength of 6.4 MA/m can be achieved within 3 minutes with maximum current of 77 A at a maximum voltage of 5.8 V.

After calibration of both quantities discussed above Kerr rotation and ellipticity hysteresis cycles, θ_K vs. H and ϵ_K vs. H , are recorded in order to study the magnetic and magneto-optic properties of the samples. The Kerr cycles give information e.g. about magnetization via the Kerr amplitude, magnetic stiffness via the coercivity or the saturation magnetic fields strength and magnetic anisotropy via the shape of hysteresis loops of the magnetic materials.

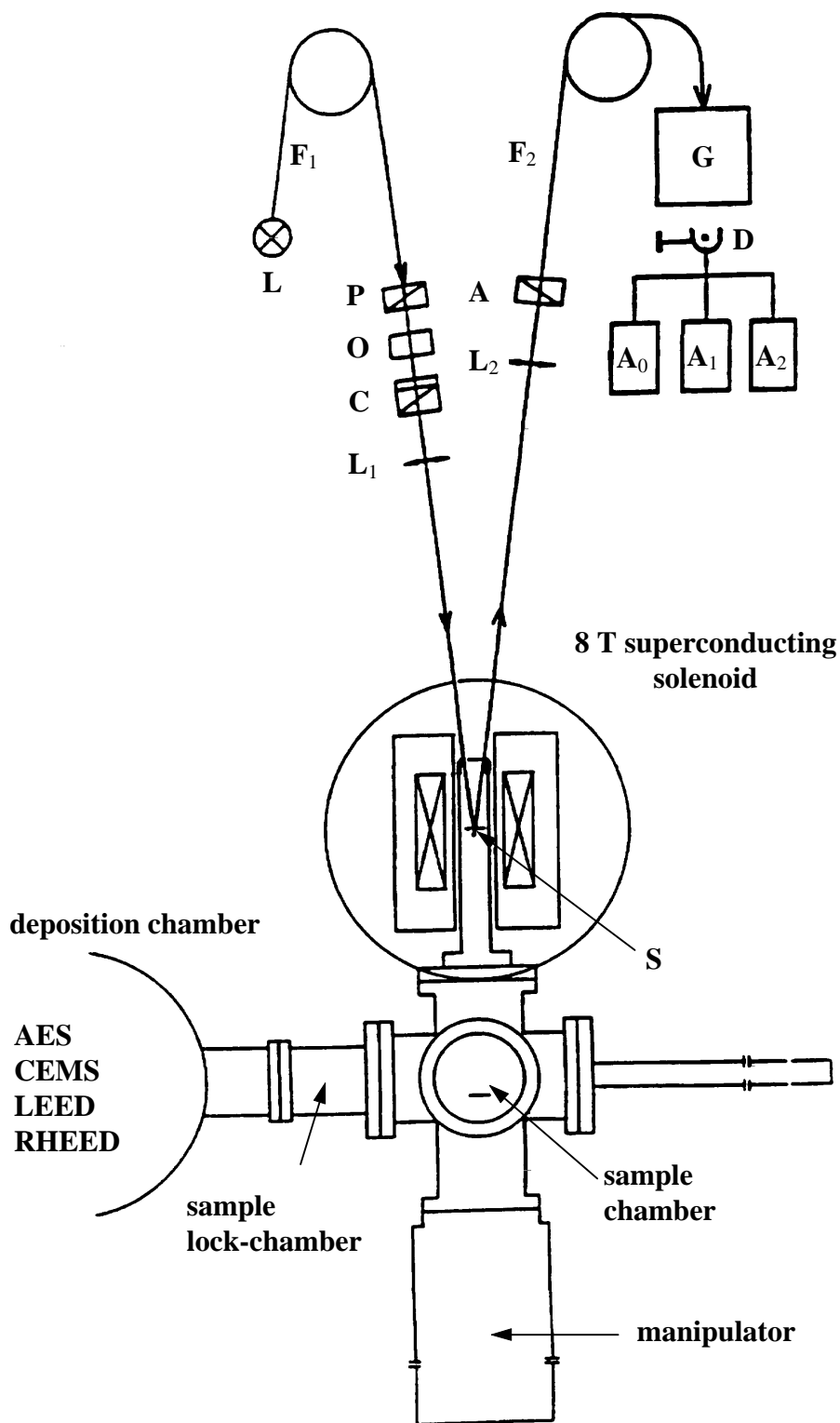


Fig. 3.3: Schematic representation of the polar UHV Kerr Spectrometer

Legend:

Abbreviations	Expressions
L	150W Xenon high-pressure Lamp
F_{1,2}	Optical fibres
P, A	Glan-Thomson-air polarizing prisms
O	Elasto-optic modulator
C	Babinet-Soleil type compensator
S	Sample
L_{1,2}	Lenses
G	Monochromator
D	Photomultiplier
A_{0, 1, 2}	Lock-in amplifiers
