In the following chapter we want to consider the magnetic properties of nanoscaled wires. They are characterized by a large aspect ratio of their length to their width and height. We will distinguish between wires with a width in the sub-micrometer regime on the one hand and those which are built up by only single atoms on the other hand. It is obvious that such systems exhibit a pronounced anisotropic behavior due to its shape.

13.1 Wires Exhibiting a Width in the Sub-Micrometer Regime

Let us assume that the height and the width of the wire is in the sub-micrometer regime whereas the length is significantly larger. This implies a high aspect ratio. One example of such a system is presented in Fig. 13.1. The sample is a thin Fe film of 13 nm thickness which has been transformed into a periodic nanoscaled wire array by an anisotropic plasma etching process after film deposition. The Fe film was grown on an Al₂O₃(11̅02) substrate onto a 150 nm thick Nb buffer layer which has a (001)-orientation as can be derived from the three-dimensional epitaxial relationship between niobium and sapphire. Finally, an array of well separated Fe wires on top of a Nb buffer is obtained. The measurement confirms the regularity of the Fe nanoscaled wires having a width of 150 nm and a periodicity of 300 nm as well as that the wires are completely separated from each other. The stripes have a sinusoidal shape.

Due to the shape anisotropy the magnetization is expected to be oriented along the wire. The upper part of Fig. 13.2 shows the remanent Kerr signal \( \theta_{rem} \) normalized to the Kerr signal at saturation \( \theta_{sat} \) as a function of the angle of rotation \( \chi \) about the surface normal of the Fe film which yields information about the squareness of the hysteresis loops. The signal \( \theta_K \) represents the rotation of linearly polarized monochromatic light due to the reflection on a
ferromagnetic surface. This experimental technique is known as the magneto-optical Kerr effect (MOKE). According to Fig. 13.2 the remanent Kerr signal is significantly reduced at certain angles $\chi$ without reaching zero-values signifying the hard axis orientations (around 90° and 270°). For the corresponding angles $\chi$ along the easy axis orientations (0° and 180°) the ratio $\theta_K^{\text{rem}} / \theta_K^{\text{sat}}$

**Fig. 13.1.** Surface morphology of a periodic array of Fe nanowires on a Nb/sapphire substrate imaged with atomic force microscopy AFM. (Reprinted from [40] with permission of IOP)

**Fig. 13.2.** The upper panel shows results from hysteresis loop measurements at different angles of rotation $\chi$ for the nanowire array as measured at remanence normalized to the Kerr rotation as measured at saturation. The lower panel depicts the results of MOKE hysteresis loop measurements as a function of the angle of rotation of the unpatterned sample where $\theta_K^{\text{rem}}$ as measured at remanence is normalized to $\theta_K^{\text{sat}}$ as measured at saturation and plotted as a function of the angle of rotation $\chi$ which is a measure of the magnetic anisotropy. (Adapted from [40] with permission of IOP)