In the following, experimental and theoretical results are reviewed which describe the effect of a grating on the propagation of SPs. Similar to Chap. 3 first the emission of light, enhanced by SP excitation, is discussed at smaller amplitudes of the grating; it is compared to that of gratings without SP excitation. Stronger corrugation leads to changes of the dispersion relation of the SPs which can be recognized by the changes in position of the reflection minima with increasing roughness. Correlated with the excitation of SPs, the electromagnetic field at the surface is enhanced in a similar fashion to smooth surfaces; the importance of the enhancement for the generation of the second harmonic and for the surface enhanced Raman scattering (SERS) is discussed. If SPs are reflected at the grating under special conditions, the reflected and the primary SPs couple with each other and energy gaps are produced.

A rough surface can be decomposed into its harmonic components with a continuum of \( k_r = \frac{2\pi}{a} \) values. It is therefore promising for a better understanding of the SP-phonon interaction to look at a surface containing only one of these components, i.e., gratings described by \( S(x) = h \sin(\frac{2\pi}{a}x) \).

This restriction on a sinusoidal profile brings not only a simplification in the experiments since a holographic or interference grating can be better reproduced than a rough surface, the theoretical treatment is also easier.

The experiments can be performed in two ways:

a) The ATR Method. Here the silver/air interface has the profile of a grating, see Fig. 6.1. The gratings are produced by vaporizing a metal film, e.g., Ag of about \( 5 \times 10^2 \) Å thickness, on a photoresist grating which has been prepared by illuminating a plane photoresist (Shipley AZ 1350) film, deposited on a glass
or quartz slide, with the interference pattern of light of wavelength \( \lambda \). Chemical development of the illuminated photoresist film yields a sinusoidal profile [6.1–3]. The amplitude \( h \) of the profile, which depends on the time of exposure, is obtained by measuring the relative intensity of its first-order diffraction with \( s \)-polarized light using the relations given below.

This device can be used in two ways: either observing the reflected beam or looking at the light scattered from the grating surface, "scattering device".

\[ 6.1 \]

\begin{itemize}
\item \textbf{b) Reflection Method.} The light coming from the air side is reflected at the surface of the grating described above, see Fig. 6.2. This is the classical device for light spectroscopy with gratings. Here the SPs are produced via a grating coupler, see Sect. 2.7.
\end{itemize}

Both experimental devices have been used. The results are described in this chapter.

\[ \text{Fig. 6.2. Reflection of light at a grating} \]

6.1 Emission of Light from Sinusoidal Gratings Supported by Surface Plasmons

Analogous to the observation on rough surfaces, the excitation of SPs on gratings can be observed by the emitted light. In the experimental arrangement, see Fig. 6.1, the rough surface has been replaced by a metal film with a sinusoidal surface. In contrast to rough surfaces the scattered intensity is concentrated in some needle-like diffraction maxima. Figure 6.3 demonstrates the light emission into the \((-1)\)th diffraction order at the air side as a function of the angle of incidence \( \theta_0 \) for two \( h \) values: \( h = 3.3 \, \text{Å} \) (above) and \( h = 160 \, \text{Å} \) (\( h \) is the amplitude of the sinus profile) [6.4]. On the left the correlated reflection curve is reproduced. Both (a) and (b) differ in position and width due to the different value of \( h \). The maximum excitation produces maximum light emission. The resonance case is not completely adjusted in Fig. 6.3, since the reflection minimum does not reach zero.