

# Solid State Optics

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Versuchsdurchführung: ?? . ?.???

Protokollabgabe: ?? ??

## 1 Introduction

Fourier Transform Infrared (FTIR) spectroscopy is a powerful method for determining the electronic properties of metals and semiconductors. The FTIR technique is based on the interaction of infrared light with the material. Reflection and transmission are used to determine important electronic properties. Especially for semiconductors, the FTIR method is particularly useful because it helps to adjust parameters such as the doping concentration or the bandgap. For building applications like LEDs, transistors, or solar cells, precise knowledge of the bandgap and doping concentrations is required. In contrast to other common methods, such as spectroscopy with a monochromator, the FTIR method is much faster and more precise. Instead of varying the wavelength through multiple measurements, the FTIR method can measure the entire spectrum at once due to the use of a Michelson interferometer, which enables the interference of light. After Fourier transformation, the complete spectrum is obtained in a single step.

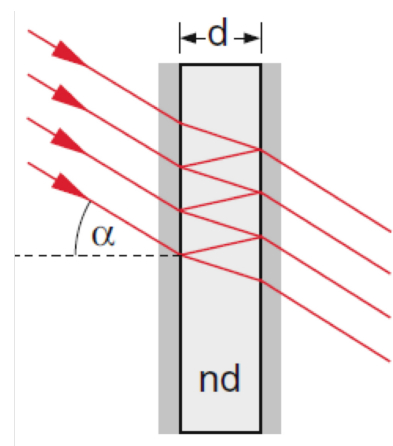
Firstly, the theoretical basics of light-matter interaction and some important formulas regarding reflection and transmission will be discussed. Following this theoretical introduction, the experimental setup will be described. The final part of this paper will focus on data evaluation, starting with the gas absorption of air. The second part of the data evaluation will involve determining the signal-to-noise ratio. The last part will address the determination of several previously mentioned electronic and optical properties, such as the refractive index, extinction coefficient, absorption coefficient, bandgap, and pulse matrix element for all

given semiconductor samples.

## 2 theory

### 2.1 Plane parallel layer

The investigated semiconductor samples can in first approximation be described as a plane parallel layer 1 with a thickness  $d$  and refractive index  $N_2$  which acts like a fabry-perot interferometer. Light is simplified



**Abbildung 1:** Simplified illustration of the measured samples as a plane parallel plate with thickness  $d$  and refractive index  $N_2$ . The surrounding air is described with a refractive index  $N_1 \approx 1$  [1]

as beams. Every incoming beam is partially reflected and partially transmitted at the first interface. The

total power reflectivity  $R_1$  is described with:

$$R_1 = \left| \frac{1 - N_2}{1 + N_2} \right|^2 \quad (1)$$

without considering the phase shift of the reflected beam. Like shown in the illustration, the total power reflectivity of the second interface  $R_2$  consists of the incoming beams and the beams reflected at the first interface within the material. Additionally, the absorption of the material is considered. Therefore,  $R_2$  is described with:

$$R_2 = R_1(1 - R_1)^2 \cdot e^{-2\beta d} \quad (2)$$

with the absorption coefficient  $\beta$  and the total power reflectivity  $R_1$  of the first interface. The assumption that the reflection of the first interface is the same as the reflection of the second interface is in reality not correct. Disturbances like roughness of the interfaces or the absorption of the material lead to a different reflection coefficients of the two interfaces.

Considering this and the phase of the light, the total power reflectivity  $R$  is described with:

$$R = \left| \frac{(e^{i\frac{2\omega}{c}N_2d} - 1)(1 - N_2)}{e^{i\frac{2\omega}{c}N_2d}(1 - N_2) - (1 + N_2)} \right|^2. \quad (3)$$

### 3 Set-Up

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### 4 Bibliography

#### Literatur

- [1] Meschede D., *Gerthsen Physik*, Springer Verlag, 25th Edition, 2018. Modified by Lukas Hein and Elias Schwarzkopf.