Generalized Ellipsometry and Complex Optical Systems - Spontaneously Ordered AlInP and GaInP

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PREFACE

The more insight is needed and the more effort is spent, the more questions appear. Today's subjects in science and engineering have reached high complexity based on the exploitation of the technological possibilities available at this time.

The objective of the thesis is the spectroscopic characterization of a structural property that arises during the epitaxial growth of and within many semiconducting materials. The so called atomic order causes the vapor-phase grown III-V semiconductor compounds to show non-scalar dielectric susceptibilities. An adequate tool to obtain the thesis goal shall be spectroscopic ellipsometry which owns remarkable sensitivity to minute optical properties of thin-films. Among the polarization-dependent optical techniques spectroscopic ellipsometry has become a standard method in order to explore the optical properties of solids and liquids. However, until today most of the results obtained with ellipsometry are reported from isotropic materials. Investigations on arbitrarily anisotropic layered systems or samples with geometrical structures of high complexity are mainly restricted to data collection and qualitative analysis. This is because of

(1) the complex formulas associated with highly anisotropic systems, and

(2) standard ellipsometry is related to structures which need to behave isotropic with respect to the light propagation.

Hence, a convenient mathematical formalism is necessary that enables the calculation of the optical response of a given layer structure. Likewise, appropriate experimental setups are derived which allow for the determination of non-redundant optical parameters of the anisotropic sample.[a)]

In this thesis a highly analytical processed matrix algebra is presented including special solutions for homogeneously twisted materials such as twisted nematic liquid crystals. The algebra allows for the computation of a given layer stack and the calculation of the JONES reflection and transmission matrices of the *entire* sample setup. In fact, the JONES matrix of an arbitrary optical system is the most general approach in order to connect predefined incident and observed exit plane electromagnetic waves. Therefore, novel techniques are introduced in this thesis which enable the determination of JONES matrix elements of arbitrary optical systems, such as anisotropic thin-film bulk structures.

Having developed the theoretical and experimental basis for the characterization of *anisotropic* layered structures, the objective of the thesis can be reached by applying the old but sophisticated technique - polarization-dependent optical spectroscopy.

[a)] For a comprehensive review of the present-day state of data analysis in spectroscopic ellipsometry, see G.E.Jellison Jr., in *Spectroscopic Ellipsometry,* edited by A.C.Boccara, C.Pickering, J.Rivory (Elsevier, Amsterdam, 1993), p.416 (Proceedings of the 1st International Conference on Spectroscopic Ellipsometry, Paris, France, 1993)

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