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Subject:
Review of the habilitation thesis of Jan Mistrík, Ph.D., "Light polarization - a probe of nanomaterials: Application of spectroscopic ellipsometry and magneto-optics".

As the title suggests, the common topic of the thesis is the polarization of light and its application to the investigations of materials with several spectroscopic methods: ellipsometry, magneto-optics, and scatterometry.

In the first part, the author introduces the essentials of light-matter interaction, ellipsometry, and magneto-optics. Step by step, a reader is introduced first to elementary topics, e.g., Maxwell equations and principals of ellipsometry on isotropic samples, followed by an introduction to advanced topics of ellipsometry on anisotropic materials, scatterometry, and magneto-optical Faraday, Voigt and Kerr effects. The general theoretical parts are often illustrated by experimental examples from the author's experience. The introduction is rather detailed and spans almost 100 pages, and as such, it can serve well as an introductory text for students. Indeed, parts of the introductions are an expanded version of a book chapter that the author previously published.

The second part of the thesis summarizes the author's contribution to the scientific field and presents selected papers. The review of publications is structured into several topical sections that I briefly summarize below.

The first section is devoted to investigations using both spectroscopic ellipsometry and spectroscopic magneto-optical Kerr effect. The research involved iron oxides ($NiFe_2O_4$, $CuFe_2O_4$), manganese oxides ($La_{2/3}Sr_{1/3}MnO_3$), and cerium doped yttrium iron garnet. The investigations using both ellipsometry and magneto-optics allowed the determination of diagonal and off-diagonal elements of the permittivity tensor, thus bringing a more comprehensive understanding of the optical and magneto-optical response. For example, in work on $NiFe_2O_4$, the very good agreement between measured longitudinal Kerr rotation spectra and those calculated based on results from ellipsometric and polar Kerr rotation measurements showed consistency of the obtained permittivity tensor.

Another large set of publications was devoted to the determination of optical constants using ellipsometry. The work consisted of investigations of nickelates ($LaNiO_3$), titanates ($PbZr_{1/2}Ti_{1/2}O_3$), nitrides (TaN, VN), fluorides (FeF_2) and chalcogenides (MoS_2, Sb_2S_3, Sb_2Se_3)

that allowed either determination of optical constants of materials that have not been analyzed yet or refinement of existing optical constants.

A significant amount of work was devoted to the investigation of nanostructures, e.g., nanocrystalline diamond, doped cerium and zinc oxide (Co-CeO_2, Sn-ZnO), gold nanostructures and orthoferrites ($SmFeO_3$). For example, the work on nanocrystalline diamond films prepared by PECVD showed that high-quality diamond films were grown at lowered substrate temperatures under optimized growth conditions. These films exhibit a high refraction index and low extinction coefficient approaching those of a bulk diamond. Application-oriented research was devoted to a correlation of optical and mechanical properties of polymer VTES films.

Several papers were focused on the investigation of multilayers, e.g., Co/Cu multilayers, omnidirectional mirrors, and Fe_2O_3/NiO_3 multilayers. Here I would like to highlight the work on Co/Cu multilayers that explored the optical and magneto-optical differences in multilayers that are ferromagnetically or antiferromagnetically coupled. It turned out that the longitudinal and polar Kerr rotation spectra and the spectra of the effective index of refraction significantly differed in multilayers with the two couplings, which indicated that the optical constants of the non-magnetic metal spacer determine the exchange interaction.

Another section was devoted to scatterometry, which allows the characterization of laterally periodic structures. Several papers were dedicated to optical scatterometry on Ni gratings and magneto-optical scatterometry on permalloy gratings. In the latter, the measurements and modeling of the magneto-optical spectra, both in specular reflection and the first-order diffraction, evidenced the oxidation of the Cr coating of the permalloy wires and the presence of SiO_2 on the exposed part of the silicon substrates.

The characterization of complex heterostructures using ellipsometry was demonstrated by works on $MoTe_2$ nanosheets and on solar cell heterostructures consisting of nanotubular TiO_2 coated with CdS photosensitizer. In the latter, the ellipsometric measurements showed that the redshift of the onset edge of the photon-to-current efficiency spectrum was caused by the sub-band-gap tail of the CdS coating. The results indicate possible improvements in the performance of the heterostructures used in the solar cells.

The author was directly involved in several application-oriented research and collaborations with several companies: Murakami Kaimeido, Ltd., Komatsu Electronics, Ltd. from Japan, Ella-CS, s.r.o., Toseda s.r.o., and Synthesia, a.s, from the Czech Republic. The work involved either the analysis of the heterostructures using ellipsometry or the design of an ellipsometric setup for in-situ monitoring.

In summary, the habilitation thesis of Jan Mistrík, Ph.D., represents highly impressive scientific and pedagogical achievements. The well-elaborated introductory part demonstrates the author's excellent pedagogical skills and will be useful for students as a helpful introduction to ellipsometry and magneto-optics. The contribution to the scientific field is based on the author's extensive publication record comprising more than 60 peer-reviewed papers and a book chapter, many highly cited. The author's expertise includes several methods, e.g., ellipsometry, magneto-optical spectroscopy, and scatterometry, and involves fundamental, applied research and even collaborations with industry. Based on the results of the originality check by the Turnitin system, I see no indications of plagiarism. In my view, the presented thesis, without any doubt, deserves to be accepted as a successful habilitation thesis.

Yours sincerely

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