Chapter 7

Functionalization of Surfaces with Optical Coatings Produced by PVD Magnetron Sputtering

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ABSTRACT

This chapter describes the functionalization of the surface of the glass through thin film inorganic coatings. Such filters called dichroic filters, following the physical principle of interference of light using the rules of optical physics. The design of the optical multilayer materials with high and low refractive index and optimizing the predetermined optical responses. The AFM quantify the real thickness and, calibrate the deposition plant, using as an input data for the simulation to evaluate the dispersion index refraction and absorption. The dichroic filters separate the incident radiation into two or more predetermined optical bands. The materials used are deposited using PVD Reactive Magnetron Sputtering, allows to increase the deposition rate, to obtain good homogeneity range of the surface deposited. The set point of deposition which allows to obtain stoichiometric oxides is analyzed with the technique RBS. These optical filters, also called dichroic are applied in the research field of the splitting photovoltaic concentration.

INTRODUCTION

An optical filter that selectively, transmits light in a particular range is known as a dichroic or interference filter. These filters exploit the interference phenomenon to form multiple reflections between the different layers of a multilayer thin film. This effect permits to increase or decrease the reflectance of an optical surface in the visible and the near infrared spectrum (Asghar, Shoaib, Placido, & Naseem, DOI: 10.4018/978-1-5225-0066-7.ch007)
Versita 2008). The dichroic filters are applied in the concentrated photovoltaic (CPV) research field in order to split the solar radiation into two or more optical bands and send them to photovoltaic cells with different energy gaps. This enables to fabricate a tandem cell system coupled with optical lenses and to increase the energy yield and the overall efficiency of the CPV module compared to conventional PV modules (A.G. Imenes, 2004).

This chapter will focus on the functionalization of glass surfaces through the application of thin film coatings. An overview of an optical multilayer coating is described outlining the design, the fabrication and the characterization of the thin film.

The design of the optical multilayer requires the evaluation of the optical characteristics of the substrate glass material, including its refractive index and the absorption coefficient. This is done applying analytical discrete functions to only slab materials. Optical multilayer coating design provides the evaluation of the optical constants of the materials used in the deposition step. Using such materials it can be simulated a stack, formed of alternating oxides layers, which allows to optimize the sequence of films with high and low refractive index optimizing the predetermined optical response (Mazuri, et al., 2013).

The PVD reactive magnetron sputtering technique is used to fabricate the optical multilayer. Single layers of TiO₂ and SiO₂ are deposited by reactive magnetron sputtering. The oxide coating is prepare from a metallic target. The poisoning of the metallic target realized by oxygen gas is controlled retroactively by a voltage system imposed on target by power supply (Lou, et al., 1999). After the fabrication the Rutherford backscattering spectrometry (RBS) and the spectrophotometric analysis (UV-Vis-NIR) are employed to analyze the chemical and physical properties of the oxide materials. Finally some typical applications of the multilayer in the field of photovoltaics are described.

**PHYSICS OF THIN FILMS**

In the field of geometrical optics, each optical phenomenon is connected with the interaction of electromagnetic radiation with matter. The classical description of electric and magnetic fields in matter (O.Stenzel, 2005), (Ohring, 1992) is given by Maxwell’s Equations (Macleod, 1986):

\[
div \vec{B} = 0 \quad B = \mu_0 \left( H + M \right) \tag{1}
\]

\[
\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \tag{2}
\]

\[
div \vec{D} = 0 \tag{3}
\]

\[
H = \frac{\partial D}{\partial t} \quad D = \varepsilon_0 \vec{E} + P \tag{4}
\]

where \( \vec{E} \) and \( \vec{H} \) are respectively the vectors of the electric and magnetic field strength, \( B \), and \( D \) respectively represent the magnetic field and electric displacement, \( P \) is the polarization density, and \( M \) is the magnetization.
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