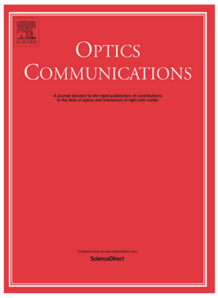
Accepted Manuscript



Physical thickness and group refractive index measurement of individual layers for double-stacked microstructures using spectral-domain interferometry

Jungjae Park, Jaeseok Bae, Jong-Ahn Kim, Jonghan Jin

PII: S0030-4018(18)30805-8
DOI: https://doi.org/10.1016/j.optcom.2018.09.024
Reference: OPTICS 23463

To appear in: *Optics Communications*

Received date : 29 June 2018
Revised date : 10 August 2018
Accepted date : 10 September 2018

Physical thickness and group refractive index measurement of individual layers for double-stacked microstructures using spectral-domain interferometry

Jungjae Park[a,b], Jaeseok Bae[b], Jong-Ahn Kim[a], and Jonghan Jin[a,b,*]

[a] Division of Physical Metrology, Korea Research Institute of Standards and Science (KRISS), 267 Gajeong-ro, Yuseong-gu, Daejeon, 34113, South Korea

[b] Department of Science of Measurement, University of Science and Technology (UST), 207 Gajeong-ro, Yuseong-gu, Daejeon, 34113, South Korea

*Corresponding author. Tel: +82-42-868-5867, Fax: +82-42-868-5608
E-mail address: jonghan@kriss.re.kr

Abstract

A non-destructive method for measuring the physical thickness and group refractive index of individual layers was proposed based on spectral-domain interferometry, which was realized to achieve real-time measurements using a mode-locked laser and an optical spectrum analyzer. As a double-stacked specimen, a microfluidic channel mold composed of a SU-8 photoresist and a silicon wafer was chosen. With areal scanning of the sample, a physical thickness map and a representative group refractive index value for each layer were obtained at the same time. The sample was measured 30 times consecutively at pre-determined points to estimate the repeatability of the physical thickness, for which the standard deviation was less than 10 nm. Moreover, a measurement comparison with two calibrated reference instruments was conducted. According to the comparative measurement results, physical thickness values obtained by the proposed method and with each comparative method were found to be in good agreement within expanded uncertainty levels.

Keywords: physical thickness, refractive index, spectral-domain interferometer, multi-layered structure

1. Introduction

In recent years, multi-layered structures have been widely utilized to fabricate smart devices for a variety of purposes. There are numerous applications, such as stacked semiconductor devices, flexible display devices, OLED or AMOLED display panels, solar cells, electronic paper, RFID and MEMS devices, and optical filters [1-4]. Particularly, with regard to optical elements such as display panels and waveguides among these applications, their performance capabilities are sensitive to the physical thickness and refractive index of each stacked layer [5, 6]. Therefore, for optical elements having multiple layers, the quantities of both the physical thickness and the refractive index for each layer should be monitored and controlled to achieve the desired performance outcomes.

An optical interferometer is a well-established non-destructive method for measuring the optical thickness given its advantages of good precision and traceability to length standards. In this case, the physical thickness can only be determined from the optical thickness when the refractive index of the medium is provided with high precision [7-11, 19]. To circumvent this fundamental problem, several measurement methods have been proposed and realized using several optical path differences obtained by inserting and removing the sample [12-18], by rotating the sample [20, 21], and by blocking some beam paths in the interferometer layout [22, 23]. However, most of these studies utilized only single-layered samples [13-23] or measured the total thickness of multi-layered samples [12]. An interferometric method to measure the refractive index and thickness of a specific layer within a multi-layered specimen was reported in the field of optical coherence tomography, but it has practical limits when used to improve the measurement speed due to the estimation of the focus shift using numerically corrected images [25].

In this paper, a non-destructive method which can be used to measure the physical thickness and group refractive index of separate layers in a double-stacked sample is proposed based on spectral-domain interferometry, which facilitates high-speed measurements through a straightforward analysis of the interference