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Residual stress reduction in Si_3N_4/SiO_2 notch filters by reactive pulsed magnetron sputtering

Chuen-Lin Tien, Hong-Yi Lin and **Chien-Jen**
Feng Chia University, Taiwan

A notch filter is typically used in engineering applications that require effective reflection or rejection of electromagnetic wave within a specified spectral region while providing high transmission at wavelengths outside of the region being rejected. Notch filters made with discrete thin film multilayers can achieve high rejection within the reflection band, high transmission outside the reflection band, and provide excellent environmental durability properties. The residual stress in thin film multilayers is a critical factor for the optical coatings. The residual stress may affect the performance and reliability of the optical thin film components. The aim of this work is to produce notch filters with low residual stresses that satisfy certain spectral rejection band requirements. In this study, the residual stress behavior in two kinds of Si_3N_4/SiO_2 dielectric quarter-wave stacks prepared by a reactive pulsed magnetron sputtering technique was presented. The numerical simulation of multilayer stress behavior by using the MATLAB software was performed. Figure1 shows 44 layers of the $(Si_3N_4/SiO_2)22$ multilayer films, the residual stress in compressive state is -91.27 MPa for the simulation and -11.38 MPa for the stress measurement. A 45-layer of alternating quarter-wave stacks of Si_3N_4 and SiO_2, and composed of a MgF_2 buffer layer. The residual stress is -74.66 MPa for the simulation and -8.43 MPa for the measurement. The discrepancy of simulation and measurement value is mainly due to ignore the interface stress between the film layers. The results show the designed $(Si_3N_4/SiO_2)22$ quarter-wave stack with a buffer layer of MgF_2 thin film can significantly reduce residual stress. We also found that the residual stresses in two Si_3N_4/SiO_2 multilayer design cases are changed from compressive to tensile stress with increasing the elapsed time. The proposed approach described here for reducing residual stresses in notch filters could be applied to make low-stress multilayer coatings.

Biography

Chuen-Lin Tien received his Ph. D degree in Optical Sciences from National Central University (Taiwan), in 2000. He was a senior researcher in Chung Shan Institute of Science and Technology from 1987 to 2004. In 2004, he served as assistant professor in the Department of the Electrical Engineering of Feng Chia University, Taiwan. In 2010, he promoted to a full professor position. His research interests are optical design, optical thin film, optical interferometry, thin film stress measurement, and fiber-optic sensors. In 2017, he founded the Center of Thin Film and Measurement Technology to develop advanced thin-film coating technology and to strive for more academic-industry cooperation projects. He also built up an Optical Thin Film and Measurement Technique Alliance. This alliance will expand optical technology applications and promote the industrial technology upgrade.

cltien@fcu.edu.tw

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