

Abstract

Laser as a weapon used in contemporary warfare has been very common.

As an important part of laser weapons, thin film plays an important role in laser attack and defense equipment.

The manufacturing technology of graded-index thin film has always been a focus in the field of military science and technology and one of the key technologies to promote the development of laser weapons.

This paper summarizes the present domestic situation of the graded-index thin film coating, and specifically introduces the application of graded-index thin film in laser equipment.

Introduction

The structure of the graded-index thin film is essentially different from that of the traditional optical film, the physical properties and microstructure change continuously in the longitudinal direction, and there is no mutation interface, so the film has a better performance than the traditional optical film in terms of low scattering loss and high LIDT [1-5].

In this paper, the result characteristics and performance advantages of graded-index thin films are introduced, the preparation technology and process status of graded-index thin film are summarized, and the prospect of military applications is analyzed.

Structure

- The film stack dislocation designed by Rugate theory is shown in figure 1.

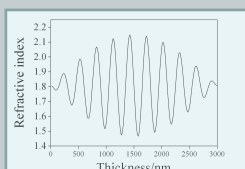


Figure 1. Graded-index curve.

- The graded-index thin film is divided to N child layers along the normal direction, the physical thickness of each layer is equal and their refractive index are uniform, as shown in figure 2.

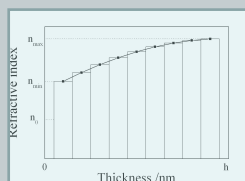


Figure 2. Graded-index hierarchical equivalent diagram.

- The periodic refractive index structure refers to that the refractive index of the odd layer (even layer) of the film layer varies, while the refractive index of the even layer (odd layer) is constant. The refractive index variation trend of this film stack is similar to that of the Rugate theory to some extent, and can be called rugate-like, as shown in figure 3.

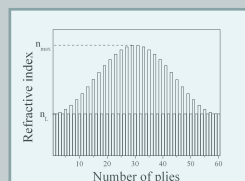


Figure 3. Periodic graded-index bar graph

Structure

- Compared with traditional thin films, the main characteristic of the graded-index thin film is to reduce the effect of material interface mutation when the high and low index film layers alternate in the film stack structure.

Preparation technology

A practical method for preparing graded-index thin films is to mix two or more different index materials to obtain a monolayer with any index in the middle, and then to prepare characteristic films for specific spectral requirements [17].

How to obtain a monolayer with any middle refractive index is the real difficulty in the process of graded-index thin film coating.

In order to achieve this, the key is to ensure that the components of the film materials are mixed in a stable manner according to the expected proportion, so the refractive index is controllable during the preparation process.

Combined with the existing experience, from the perspective of the preparation technology, the target material co-sputtering method is easy to control. Ion beam deposition is also unique among various. In conclusion, ion beam sputtering can combine the advantages of target sputtering and ion beam deposition. Although it is difficult to carry out, it is more feasible for the preparation of high-precision graded-index thin films.

In addition, in order to obtain high-precision graded-index thin films, developing the graded-index thin film stack design software that can be connected with the equipment is also crucial.

Typical applications

- Graded-index high reflective films and their typical applications

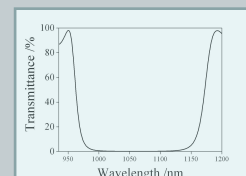


Figure 4. High reflective film.

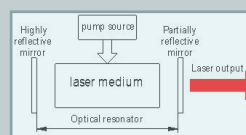


Figure 5. A typical structure of laser devices.

- Graded-index comb notch filter and their typical applications

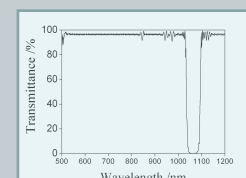


Figure 6. Notch filter.

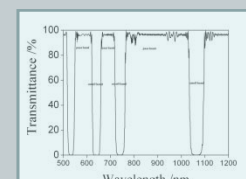


Figure 7. Comb notch filter.

- Due to the continuous change of refractive index, graded-index comb notch filter can replace many materials lacking in traditional optical thin film design.
- The comb notch filter film has become an urgent military requirement in the field of laser countermeasure.

Conclusion

The development direction of graded-index thin film is clear enough, but the practice needs further exploration.

In the past decades, the design and preparation technology of graded-index thin films have made significant progress, but the preparation difficulty is still very high.

The author hopes that the publication of this paper could promote the application of graded-index thin films, and it will influence the technical progress of laser attack and defense equipment.

Reference

- ISO 21254-1~4:2011, MOD Lasers and laser-related equipment—Test methods for laser-induced damage threshold.
- TANG Jin-fa, GU Pei-fu, LIU Xu, et al. *Modern Optical Thin Film Technology* [M]. ZHEJIANG UNIVERSITY PRESS, 2006.
- QIAO Zhao. *Graded Index High-reflective film Coatings and the research of its LIDT* [D]. China Academy of Engineering Physics, 2014.
- XIONG Feng, QIAO Xue-liang, CHEN I ang-guo, SUN Long. *Progress in research dielectric multilayer coating highly reflective of laser resonator*[J]. *Chongqing: LASER JOURNAL*, 2002: 23 (01) : 1~4