INVESTIGATION OF PERIODICALLY STRUCTURED THIN FILMS POLARIZERS

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Linear polarizers are integral to most laser systems for their role in controlling radiation polarization state. A wide diversity of up-to-date linear polarizers can provide an outstanding polarization extinction ratio. However, many of them come with operational inconveniences: absorptive polarizers suitable for normal incidence have a low laser-induced damage threshold (LIDT), restricting their use in laser applications; birefringent or thin-films polarizers demonstrate a decrease in polarizing efficiency at normal incidence, which becomes concerning as the trend towards miniaturization of laser systems continues. Mentioned limitations of conventional polarizers are becoming more pronounced, underscoring the necessity for alternative solutions.

In the search for high LIDT and efficient polarizing properties at normal incidence, we have focused on periodically modulated dielectric thin films. In the simplest case of single-layer coating, as a high refractive index subwavelength structure surrounded by a lower refractive index media, it features wavelength-selective resonance phenomenon [1]. Moreover, as the structure has modulation only in one direction, its optical response is also polarization-dependent. These features were employed to optimize the architecture of polarizing element for the target wavelength of 1064 nm. Subsequently, the ion beam sputtering technology was used to conformally deposit dielectric coatings on the structured substrate. The potential of fabricated elements for laser applications were evaluated by LIDT 1-on-1 test for nanosecond pulses.

Experimentally demonstrated niobium oxide single-layer polarizing element showed 788:1 polarization ratio for 1064 nm at normal incidence. The LIDT values of periodically modulated single-layer structure have reached 0.7 J/cm^2 and 3.1 J/cm^2 for *S*- and *P*- polarizations, that is more than six times smaller values than of planar layer. This difference in optical resistance can be explained with increased electric field intensity in modulated structure, determining damage at relatively low energy densities. To improve optical resistance, wide bandgap dielectrics as hafnium and aluminum oxides were used to create multilayer architecture. Enhanced LIDT values have reached 1.6 J/cm^2 and 18.5 J/cm^2 for *S*- and *P*- polarizations, respectively. However, nearly 2 μm thick coating with modulation discrepancies led to optical characteristics distortions which reduced the polarization contrast. The presented results demonstrate the potential possibilities of periodically structured thin-film polarizers and also highlight challenges to be dealt with in the ongoing work.

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[1] L. Grinevičiūtė, J. Nikitina, C. Babayigit, ir K. Staliunas, „Fano-like resonances in nanostructured thin films for spatial filtering“, Appl. Phys. Lett., t. 118, nr. 13, 2021, doi: 10.1063/5.0044032.