M-Lines spectroscopy validation

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Introduction

The refractive index and thickness of thin films and crystals can be determined with M-lines spectroscopy, which is based on the optical coupling between a high refractive index prism and the film to be characterized. The prism-film coupler is a device that measures the spectrum of the film propagating modes, by measuring the relatives' angles, from which the refractive index and the thickness of the film can be determined. However, using this measurement mode can generate several sources of result variability; therefore, it is necessary to validate results obtained by M-Lines spectroscopy. This statistical study was performed to assign a degree of confidence to this technique.

Experimental Conditions

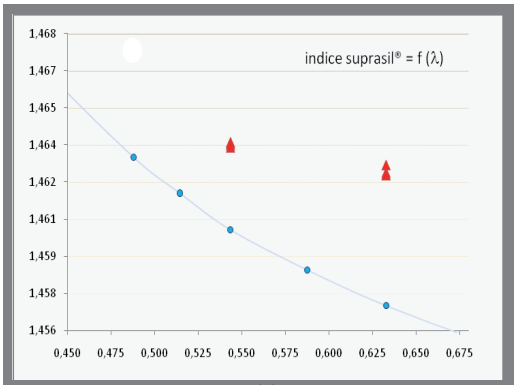
Different samples of thin films from the suprasil® family as well as a YAG undoped crystal, were used to study statistical parameters of validation such as: reproducibility, repeatability, accuracy, and uncertainty (linked to the fixing of zero and its impact on the measured results). All validation tests were performed: by one or differing persons, on the same or differing days, with different laser sources (488; 543.5 and 632.8nm).

Results and discussion

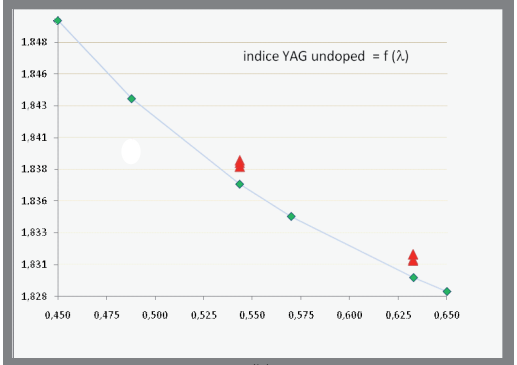
Statistical tests used in this study, have shown that results obtained by M-Lines spectroscopy are valid. The M-lines spectroscopy showed good precision (thickness: $\Delta e = 10^{-3}$ µm; index: $\Delta e = 10^{-4}$), repeatability and reproducibility. Unfortunately, the accuracy parameter was not validated; this can be attributed to a lack of thin film samples with known indexes and thickness (fig-1). Although, the accuracy parameter has yet to be studied in the best of conditions, the M-line spectroscopy method was shown to have had better accuracy with the YAG sample than the suprasil® family sample. This difference in accuracy can be attributed to the higher purity level of the YAG crystal.

Conclusion

The M-line spectroscopy method can be used for reliable measurements of thickness and refractive indexes of thin films and crystals. Furthermore, it is a non-destructive technique for measurement of optogeometric parameters. The main source of measurement variability is the operator; to reduce variability in result measurements, it is necessary to standardize and follow a set protocol.



(a)



(b)

Fig-1: accuracy of the M-Lines spectroscopy

(a) reference values of refractive index of suprasil (line fitted) and values obtained by M-Lines spectroscopy (red triangles)

(b) reference values of refractive index of YAG undoped (line fitted) and values obtained by M-Lines spectroscopy (red triangles)

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