Final Report Summary

Measurement and Characterisation of Optical Coatings by FTIR

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Background

TFI is a small, spin-out company dedicated to the provision of thin films and processes to the precision optics markets. It has been incorporated for nearly 5 years, and just recently has begun developing multiple layer AR coatings for IR components for applications in a variety of sectors; e.g. military day and night imaging devices, commercial gas sensors, thermal cameras for fire fighting and rescue. In order to assess the optical quality of these coatings it is necessary to make IR spectral measurements, particularly in the 4-6 micron and 8-12 micron wavelength regions. Despite the universal adoption of fast FTIR spectrometers for other applications, expensive dual beam dispersive instruments are still widely preferred for measurements of optical components. This is because conventional FTIR spectrometers usually show ordinate errors from stray light produced by multiple reflections from highly reflective surfaces, typical of optical samples, and also from the non-linearity of the detector and electronics. Additionally, every optical component in the IR beam, including the source and detector, can contribute to stray reflections. Multiple reflections through the interferometer produce double modulation of the IR beam, resulting in false energy being folded back into the spectrum. This is often apparent as artefacts in regions of the spectrum of the sample being measured; e.g. highly efficient AR coatings can often have apparent transmissions of >100%. Consequently, the true optical characteristics of the sample are not recorded. TFI does not have ready access to an appropriate dispersive spectrometer and the very slow feedback for samples the company has prepared has dramatically hindered the marketing and selling of TFI's products. However, some recent test of TFI samples on an FTIR spectrometer at the Thin Film Centre has given some very encouraging optical results that are comparable to those obtained with a dispersive instrument.

The Thin Film Centre at the University of the West of Scotland (formerly University of Paisley) has extensive experience of thin film deposition and characterisation, and of optical filter design and analysis.

Scope of Project

The purpose of the proposed feasibility study is to examine in detail the optical characteristics of a number of uncoated and coated substrates, including AR coated samples, as determined by an FTIR instrument, particularly for films with high transmissions of >98%. The study will consider the theoretical and instrumental implications of the results with a view to identifying the feasibility of using FTIR optimised to this novel application.

Summary

The Nicolet FTIR spectrometer appeared to perform very well, compared to previous experiences with FTIR spectrometers, where even successive measurements produced transmission measurements varying by more than 10%. The absolute measurements were very reproducible, even when the same

sample was re-measured weeks later. Artefacts from water vapour and CO2 were fairly well controlled, although there was still some obvious residuals from CO2 in some of the spectra. This is not too concerning since it occurs over a relatively small wavelength range and could be improved by flushing the specimen chamber with dry nitrogen.

The germanium substrates appeared to give higher than expected transmission readings, perhaps because the reflectance from such substrates is very high (53% over this wavelength range) and some of the reflected energy is reaching the detector. This will be investigated in future work by introducing a small controlled tilt to the sample and experimenting with baffles. Nevertheless the deviation from theoretical results was less than 2% over most of the range and was reproducible.

Results on all coated samples were very good and theoretical calculations showed that extracted parameters of refractive index and thickness were reasonable.

The TTOM between TFI and the Thin Film Centre has produced encouraging results from a simple and relatively inexpensive instrument that would enable a thin film manufacturer to quickly and reliably scan finished optical filters and coatings in the far-infrared region of the spectrum. This is an area traditionally dominated by very slow and expensive dispersive instruments, outside the budget of small companies, leading to critical delays in obtaining feedback about the success of a deposition run for such companies. Work will continue on evaluating the latest model in the range to determine whether any of the suggested improvements can be implemented.

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