Transmission and Reflection Properties of Dielectric Materials for THz Instrumentation

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***Abstract*— The objective of this work is to present the results of measuring the refractive index and absorption coefficient of different materials (HDPE, Mylar, Zitex, Teflon, and Silicon) at 600 GHz and 1.4 THz at a temperature of 293K. The knowledge of these material properties at THz frequencies is essential in order to design low loss optics for astronomical receivers. This work draws particular attention to the polarization dependence of the reflection and transmission, which we carefully measured and compared to theory.**

INTRODUCTION

In radio astronomy, high density polyethylene (HDPE) is one of the most widely used materials for lens systems and cryostat windows. Mylar is commonly used in beam splitters (such as diplexers in heterodyne receiver or in Fourier-transform spectrometers (FTS)) and also as cryostat windows. Zitex is often used as a cryogenic IR blocking filter. Silicon has found extensive use in quasi-optic lenses and also as cryostat windows. The angular and polarization dependent transmission of these materials is investigated.

MEASUREMENTS

We developed instrumental set-ups (Fig. 1) using a solid state LO source for these measurements.

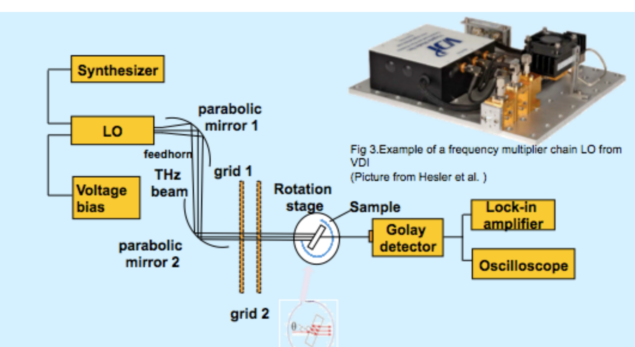

Fig. 1 Experimental set-up to measure the transmission of different materials as a function of angle and polarization.

In a first step we showed that the angular dependence of the transmission can be well described by formulas, see example fit to data at 1.4 THz.

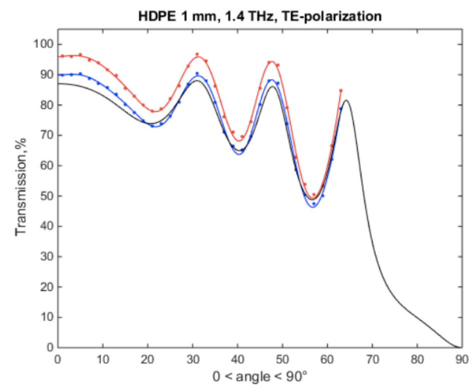

Fig. 2 Transmission of 1mm thick HDPE at 1.4 THz as a function of incident angle. The red curve shows the maximum, the blue curve the minimum of the measurements (due to standing waves, noise of the detector etc.) and the black line is the theoretical curve using the best fitting parameters for the refractive index n and the absorption coefficient alpha.

Once these were established and our measurement accuracy improved we used the formulas to derive the thickness of the sample, the refractive index and the absorption coefficient.

TABLE I
BEST FIT VALUES FOR MATERIAL PROPERTIES FOR MEASURMENTS AT 1.4 THZ

Material	Properties		
	Thickness	n Refrac. index	α (mm^{-1}) absorption coeff
HDPE	1mm 2mm	1.524 1.523 - 1.524	0.01-0.03 0.01-0.05
Mylar	100 μm 50 μm 25 μm 9 μm	1.7-2.0 1.7-2.0 1.70-1.75 1.7-1.8	0.8-1.5 0.7-2.0 1-3 1-4

Zitex	100 µm	1.2-1.25	1-4
Silicon	300 µm	3.415	0

Conclusions

We have carried out transmission measurements of different material commonly used in astronomical receivers at THz frequencies. The measurements were taken for different incident angles and different polarization and allowed us to derive the material properties.

We stress the importance of taking the polarization of the beam and its incident angle into account when building THz instrumentation.

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