FAR-INFRARED TESTING OF DIELECTRIC SHEET MATERIALS

Bernard Drouin and Richard Gagnon
College F.X. Garneau
1660 Blvd de l’Entente
Québec, PQ, Canada, G1S 4S3

INTRODUCTION

Quality control in fibre based dielectric sheet materials like paper and non woven fabric is hampered by complex manufacturing processes and usually very high production rates. Far-infrared (FIR) waves are interesting for non destructive characterization of such materials: their low scattering and moderate penetration allow accurate high resolution measurement of basis weight, fibre orientation anisotropy and dominant alignment angle. In most applications, sheet materials need to have uniform mechanical properties in order to achieve dimensional stability and problem free handling by end users’ equipment. In the case of newsprint paper for instance, small scale variations in basis weight will affect readability. Similar scale variations in fibre orientation anisotropy or angle of alignment will result in cockling, bagging, waving or curling of the sheet during the printing process. This, in turn, causes local loss of register and poor quality colour rendering, due to the multiple superimposed prints required. The herein described technique should alleviate this problem by giving the producers a way of testing their product before shipment.

After going through the basics of this characterization method, typical results involving actual production sheet materials will be presented, followed by an in depth discussion of the proposed system.

BASIC FAR-INFRARED EXPERIMENT

The above mentioned characteristics of the sheet material sample are obtained by measuring FIR transmission. As shown in the schematic presentation of the experimental set up (Fig. 1), the first operation on the FIR beam is mechanical chopping. Most FIR detectors, pyroelectric or Golay type, are sensitive to intensity variations only, consequently, chopping is mandatory, and also welcome because it allows synchronous lock-in detection thus improving the precision of the measurement.
Next comes the polarizer: determination of fibre orientation anisotropy and alignment requires a linearly polarised beam. Then, with the polarisation rotator, the experimenter can vary the angle between the beam plane of polarisation and a reference direction on the fixed sample. Measuring FIR transmission as a function of this angle yields the kind of data presented on Fig. 2.

Mean FIR transmission through most of the tested samples is an exponential function of basis weight, hence, once a sample of known mass and area has been characterised, basis weight determination for any sample of the same composition is straightforward. As illustrated on Fig. 2, FIR transmission through these samples varies with the polarisation angle, a typical dichroic material behaviour; we have established in earlier work\textsuperscript{8}, that the amplitude of this variation is related to fibre orientation anisotropy in the sample. Furthermore, the phase of this sinusoidal variation is an almost direct measurement of the dominant fibre orientation angle with respect to the reference direction, often referred to as the fibre alignment angle. This simple experimental procedure allows simultaneous determination of basis weight, anisotropy and alignment. Spatial resolution associated with this measurement depends on the beam size which can be easily modified with suitable optical components.

![Experimental set-up](image)

**Fig. 1. Experimental set-up**

![Transmission graph](image)

**Fig. 2.** Transmission as a function of the polarisation angle for A: a single polyester sample, B: two parallel tread polyester samples and C: two crossed tread polyester samples.