NOTE

Optical Evaluation of Films by Means of Moiré

The optical evaluation of a transparent polymeric film or sheeting is of considerable importance in industry, notably in the photographic and packaging fields. It is also of theoretical interest, especially with regard to crystallite size and orientation. The measurement of textural (or macroscopic) optical inhomogeneities by means of birefringence is beset with difficulties. Birefringence of oriented films if of three types, namely, intrinsic, strain, and textural. The separation of these three interdependent factors represents a formidable problem (for review, see ref. 1). An alternative approach to the problem of the morphology of films which allows a simple evaluation of large-scale (textural) optical inhomogeneities utilizes the moiré phenomenon.

Moiré patterns are the figures produced when a family of curves are overlayed with another family of curves. The subject has been considerably developed in recent years (for annotated bibliography, see ref. 2) and a semipopular account has appeared.[3] The moiré technique has been used, for example, in the direct determination without lenses of the refractive index gradient curve for diffusion in solutions.[4] In that method the optical modification in spacings of a uniform-spaced grating caused by the refractive index gradient is observed with another uniform-spaced grating. The resultant moiré pattern is directly the refractive gradient curve. In the present method, on the other hand, only a single grating is required.

The new technique may be demonstrated crudely by holding a film, such as a cellophane wrapper, about 2 in. above a photograph illustration in a newspaper. The halftone dot screen of the photograph served as the uniform-spaced grating (fourfold symmetry of dots in this case). At certain orientations of the film an enlarged moiré image is readily observed. A more dramatic means of producing the effect is to hold the film above a grating of uniform-spaced sinusoidal curves. A grating of this kind with 65 lines/in. is commercially available.[5] When the film is oriented with its direction of stretch parallel to the base lines of the sinusoidal curves, large but ragged sinusoidal moiré curves are seen. When the film is oriented with its direction of stretch perpendicular to the base lines of the grating, nothing is seen. For biaxially oriented films, the moiré figures are seen for the two directions. With a given film the moiré pattern has its greatest amplitude at some critical grating-to-sample distance. That is, the film has an effective focal length. The focal length is small with, for example, commercial low density polyethylene sheet but is large for cellophane sheets. Unoriented stereospecific polypropylene films show no effect but do show a large effect when they are permanently oriented by stretching. The greater the elongation the larger is the amplitude of the sinusoidal moiré pattern. The technique should also be applicable to biological membranes and tissues of reasonably high light transmissivity.

From an optical point of view, an oriented film may be regarded as a collection of elongated lenticular elements (cylindrical lenses) imbedded in a homogeneous medium. The focal length of these elements depends on their size and on their refractive index relative to the surrounding medium. The lens elements produce images which are slightly displaced from the unperturbed image of the grating seen through the homogeneous portions of the film. The superimposition of these two images produces the moiré pattern. The effect is akin to the moiré method for the noise-free amplification of weak signals.[6] Indeed, the moiré method for the evaluation of films may be described in terms of information theory, wherein the image of the inhomogeneous optical elements of the film serve as a modulation signal of the basic carrier wave, namely, the undistorted image of the grating. A quantitative treatment of the moiré phenomenon for films will appear elsewhere.

References

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