INFRARED IMAGING OF A STRESS-CRAZED POLYMER

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INTRODUCTION

We present experimental data on the stress-crazing of rubber-modified polystyrene under tensile load. The data were obtained by means of the simultaneous imaging of the infrared (IR) transmission through the sample, and the emission from it, during a uniform strain rate experiment. In addition, the stress and strain were also simultaneously measured and all of these results were correlated in time. Sharp changes are seen in the IR transmission and the emitted radiation at the yield point. These changes are attributed to the onset of the crazing. This crazing is detected by what amounts to "stress-whitening", but in this case using IR radiation rather than visible radiation, to which the polymer is opaque.

EXPERIMENTAL PROCEDURE

The experimental system does IR imaging of a polymer sample while it is undergoing mechanical deformation in a table-top tensile tester. The experimental arrangement is indicated schematically in Fig. 1.

![Schematic diagram of the experimental setup](image.png)

Fig. 1  Schematic diagram of the experimental setup (tensile tester not shown).
The dog-bone shaped specimen of rubber-modified polystyrene was mounted in the tensile tester, with a blackbody IR radiation source placed behind it, and an IR video camera viewing it from the front. A rotating-blade mechanical chopper was placed between the source and the sample, such that the radiation was alternately passed on to the sample and camera, or blocked. The purpose of the chopper was to permit the IR camera to alternately record the transmitted radiation in one set of frames, and the radiation emitted from the sample in another set of frames. The transmitted radiation was used to record the changes in the internal structure of the material. The emitted radiation was used to record the local changes in temperature as a function of the stress and strain. In Fig. 2, we show selected frames from the IR camera of a sample undergoing progressive strain, with blocked and unblocked background radiation. The upper left frame (#35) shows a blocked source, with no indication of a temperature rise in the center of the sample, and the upper right frame (#41) the source unblocked, with the beginning of an opaque region (dark in the image) in the central, high stress, region. The bottom pair of images, taken at later times and higher strains, show (on the lower left, with the source unblocked) a larger opaque region, within the center of which is a heated region which is emitting IR radiation, and (on the lower right, with the source blocked) one with only the emitted radiation from the hot central region. In practice, an image such as the one on the lower right is subtracted from an adjacent one (like the one on the lower left) to obtain an image which contains only the transmitted radiation.

Fig. 2. Selected frames of the IR image of the deformed rubber-modified polystyrene for blocked and open background radiation. The upper pair show a blocked source, with no indication of temperature rise in the center of the sample (upper left) and in the upper right, we have the source unblocked, and there is the beginning of an opaque region (dark in the image) in the high strain region. The bottom pair of images, taken at later times and higher strains, show (on the lower left, with the source unblocked) a larger opaque region within the center of which is a heated region which is emitting IR radiation, and (on the lower right, with source blocked) one with only the emitted radiation from the hot central region.