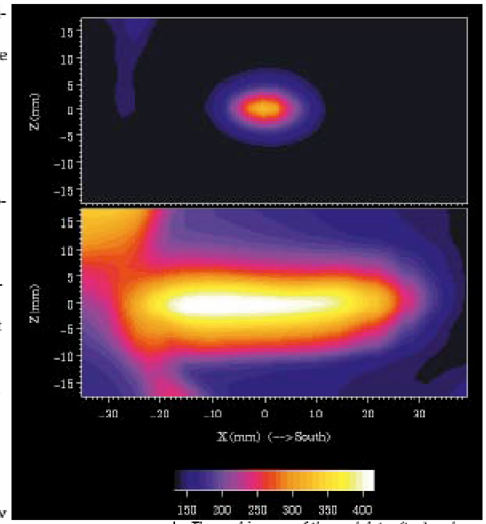
An infrared thermometer for x-ray windows

Ernie Fontes

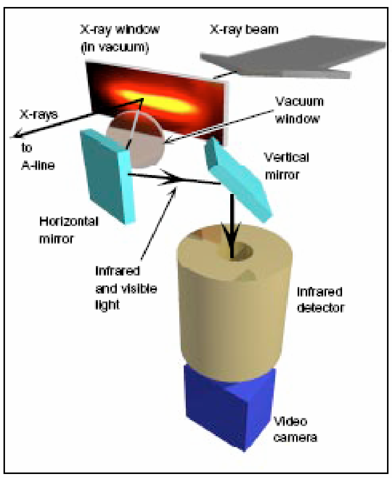
Due to the high energy of the electrons and positrons in CESR (>5GeV), the CHESS 24-pole wigglers produce an enormous amount of total synchrotron light power. At 100 mA, nearly 7 kiloWatts is incident upon the x-ray windows that separate the A and F beamlines from the storage ring vacuum.

Measuring that temperature of the window requires a remote sensing Infrared (IR) detector. Since in most instances we need to monitor only the hottest spot on the window (where the beam intersects), a simple point-focussed IR detector is suitable for the task. The advantages of a point detector (versus an IR camera) are simplicity in construction and use, robustness in harsh radiation environments, virtually no need for maintenance, and low cost.

For the past two years we have used a "Modline Plus" Infrared Thermometer from Ircon, Inc. (Niles, Illinois). The figure below shows the geometry of a typical measurement. IR and visible light pass through a sapphire (or quartz) vacuum chamber viewport, located 30 degrees off axis from the incident x-ray beam and looking at the downstream side of the X-ray window. This detector senses radiation in the 2-2.6 micron wavelength range, chosen to coincide with the range of transmission of the sapphire window, which is ≈90% transparent from 1-6.5 microns. Since CESR produces a great quantity of IR radiation, it is also important to choose a wavelength for which the X-ray window is opaque. Note that the choice of wavelength and the room temperature operation of the detector limit the measurement range from 120°C to 400°C.



Thermal images of the undulator (top) and wiggler (bottom) x-ray beams on a graphite filter (0.01 inch) on A-line. Temperatures in °C. The curved outer contours are due to the reflection of light from the inner walls of the vacuum chamber.



(Left) IR camera system monitoring the temperature of a window illuminated by the x-ray white beam.

The figure at left also shows the placement of two front-silvered mirrors that deflect the image of the X-ray window away from the beamline and below the synchrotron orbit. A coaxial view through the body of the IR detector provides access for a video camera view of the X-ray window. The IR detector has a reticle that indicates the 1 mm diameter active sensing area. Since the orientations of the two mirrors are controlled by a computer-DC stepping motor link, we can scan the entire X-ray window surface, in effect pointing the IR camera at will. Linear scans in the vertical direction show the beam height and width, and two-dimensional mesh scans produce temperature profile images (see above).

Currently this detector serves two needs. First, the measured thermal profiles are compared to finite element analysis calculations (ANSYS) as an aide in designing new heat-load-capable windows. Second, since CESR has undertaken an aggressive program to increase the stored particle beam currents, we continually monitor window temperatures so as to avoid unexpected failures. This monitoring is a small part of a labwide program to design, fabricate and test new components that are able to withstand the enormous white-light power produced by high energy synchrotron sources.