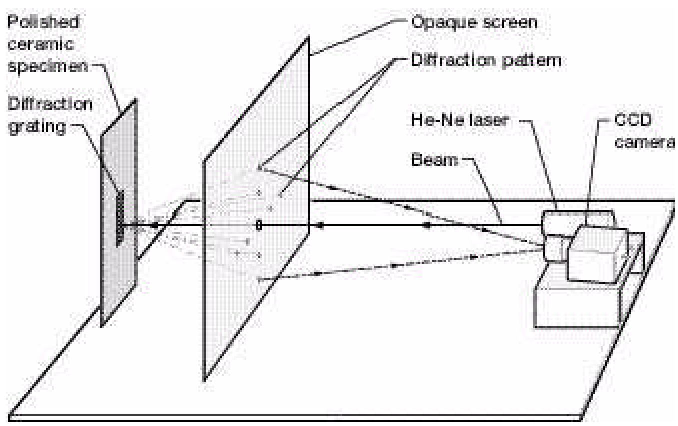
Remote, Noncontact Strain Sensing by Laser Diffraction Developed

A system was developed at the NASA Glenn Research Center for continually monitoring, in real time, the in-plane strain tensor in opaque solids during high-temperature, long-term mechanical testing. The simple, noncontacting, strain-sensing methodology should also be suitable for measurement in hostile environments. This procedure has obvious advantages over traditional, mechanical, contacting techniques, and it is easier to interpret than moiré and speckle interferometric approaches.

A two-dimensional metallic grid of micrometer dimensions is applied to a metallographically prepared gauge section on the surface of a tensile test specimen by a standard photolithographic process. The grid on the fixtured specimen is interrogated by an He-Ne laser, and the resulting diffraction pattern is projected backwards onto a translucent screen. A charge-coupled device (CCD) camera is used to image the first-order diffraction peaks from the translucent screen. A schematic representation of the system is shown in the figure.



Remote, noncontact strain-sensing system.

When the specimen is heated in a furnace, changes to the diffraction pattern can be detected. From the location of the new diffraction peaks in comparison with the initial image at the same point on the grid, all four components of the inplane deformation tensor: longitudinal, transverse and shear strain, and rigid body rotation can be calculated. In this way, bidirectional thermal expansion coefficients can be calculated. Subsequent application of the load to the specimen at a high temperature results in additional changes to the diffraction pattern. These changes are recorded and used to calculate bidirectional strain as a function of time (i.e., creep). Continuous translation of the laser to discrete spots covering the entire area of the grid on the specimen during the test period yields a real-time "map" of localized two-dimensional strain over time.

This method was developed to measure strain in relatively small, flat test specimens under controlled conditions. Modifications to the current methodology, including miniaturization, have been considered to encompass strain sensing of complex and/or curved surfaces. Further development would be required to provide in situ strain monitoring of aerosurfaces during manufacturing and use.

Glenn contact: Marc R. Freedman, 216-433-3284 or 216-433-5544, Marc.R.Freedman@grc.nasa.gov
Author: Marc R. Freedman
Headquarters program office: OAT
Program/Projects: Propulsion and Power Systems (R&T Base), HITEMP