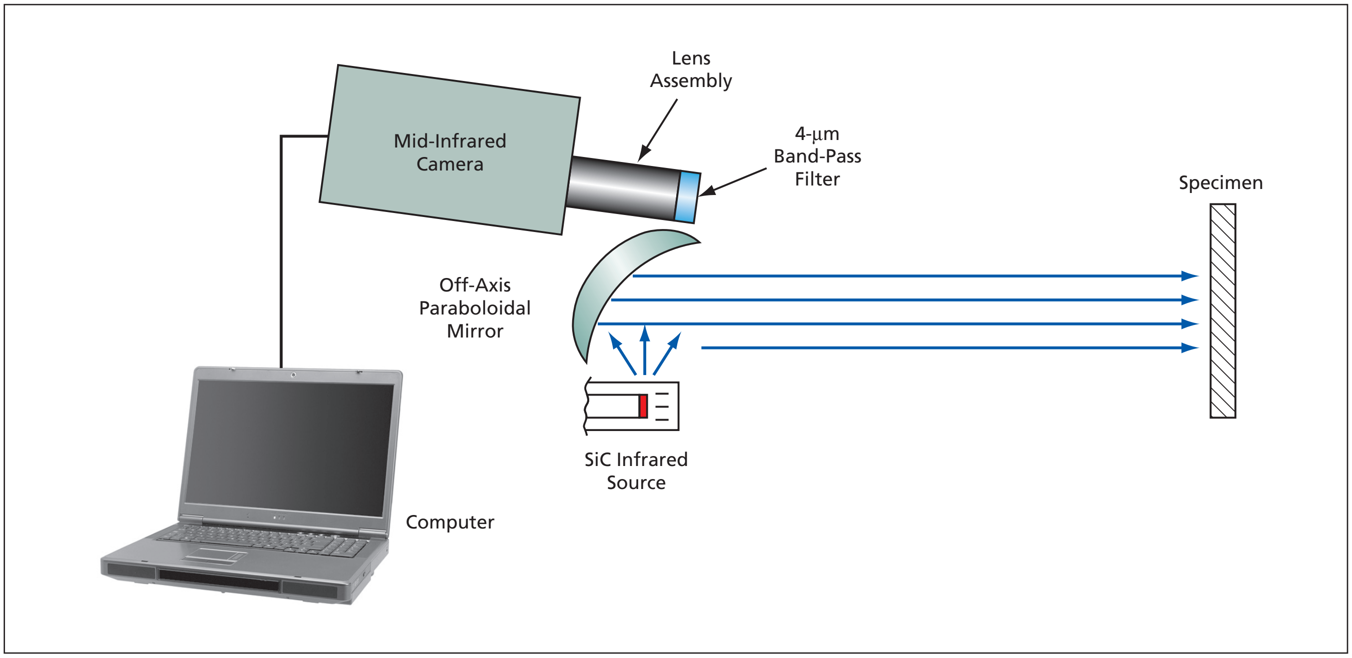


A **TBC-Coated Specimen Is Imaged** using reflected mid-infrared radiation at a wavelength of 4 µm. At this wavelength, subsurface delamination progression in the TBC that is invisible to the unaided eye becomes visible in the mid-infrared reflectance image.

Mid-infrared reflectance imaging of specimens that were thermally cycled for different numbers of cycles was performed and demonstrated that mid-infrared reflectance imaging was able to monitor the gradual delamination progression that occurs with continued thermal cycling. Reproducible values were obtained for the reflectance associated with an attached and fully delaminated TBC, so that intermediate reflectance values could be interpreted to successfully predict the number of thermal cycles to failure.

This work was done by Jeffrey I. Eldridge of Glenn Research Center and Richard E. Martin of Cleveland State University. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17950-1.

Improving the Visible and Infrared Contrast Ratio of Microshutter Arrays

Microshutters are used in the fabrication of integrated circuits and MEMS devices.

Goddard Space Flight Center, Greenbelt, Maryland

Three device improvements have been developed that dramatically enhance the contrast ratio of microshutters. The goal of a microshutter is to allow as much light through as possible when the shutters are in the open configuration, and preventing any light from passing through when they are in the closed position. The ratio of the transmitted light that is blocked is defined here as the contrast ratio.

Three major components contribute to the improved performance of these microshutters:

1. The precise implementation of light shields, which protect the gap around the shutters so no light can leak through. It has been ascertained that without the light shield there would be a gap on the order of 1 percent of the shutter area, limiting the contrast to a maximum of 100.
2. The precise coating of the interior wall of each microshutter was improved with an insulator and metal using an angle deposition technique. The coating prevents any infrared light that finds an entrance on the surface of the microshutter cell from being emitted from a sidewall. Since silicon is in effect transparent to any light with a wavelength longer than ≈1 micrometer, these coatings are essential to blocking any stray signals when the shutters are closed.
3. A thin film of molybdenum nitride (MoN) was integrated onto the surface of the microshutter blade. This film provides the majority of light blockage over the microshutter and also ensures that the shutter can be operated over a wide temperature range by maintaining its flatness.

These improvements were motivated by the requirements dictated by the James Webb Space Telescope NIRSpec instrument. The science goals of the NIRSpec require observing some of the very faintest objects in a given field of view that also may contain some very bright objects. To observe the faint objects, the light from the bright objects — which could be thousands of times brighter — must be completely blocked. If a closed microshutter is even slightly transmissive, a very bright object will still transmit a small signal, which can be larger than a signal from a very faint object transmitted through an open shutter. Since this situation can completely corrupt the results, it was necessary that the closed shutters be able to attenuate light by at least a factor of 2,000.

There currently exist four flight-quality microshutter arrays that have been fully or are currently undergoing testing and the results support that the three improvements described above have successfully led to contrast levels >50,000 in over 99 percent of the microshutters at an operating temperature of 35 K. Applications for these high-contrast microshutters are in the photomask generation and stepper equipment used to make integrated circuits and microelectromechanical (MEMS) devices. Since microshutters are a reconfigurable optical element, their versatility in these industries provides an improvement over printed masks and fixed projection alignment systems.

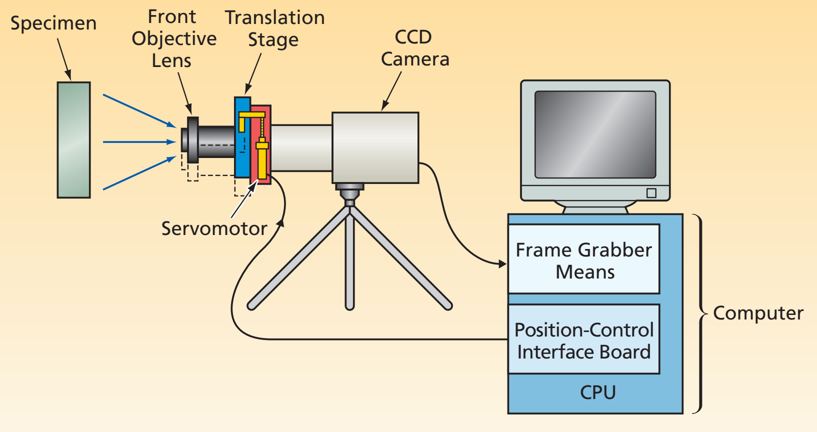
This work was done Murzy Jhabvala, Mary Li, Harvey Moseley, Dave Franz, Yun Zheng, and Alexander Kutyrev of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC- 15609-1

Improved Scanners for Microscopic Hyperspectral Imaging

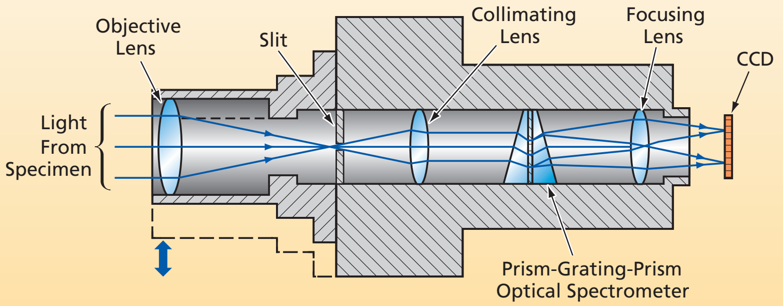
Neither specimens nor entire optical assemblies would be moved.

Stennis Space Center, Mississippi

Improved scanners to be incorporated into hyperspectral microscope-based imaging systems have been invented. Heretofore, in microscopic imaging, including spectral imaging, it has been customary to either move the specimen relative to the optical assembly that includes the microscope or else move the entire assembly relative to the specimen. It becomes extremely difficult to control such scanning when submicron translation increments are required, because the high magnification of the microscope enlarges all movements in the specimen image on the focal plane. To overcome this difficulty, in a system based on this invention, no attempt would be made to move either the specimen or the optical assembly. Instead, an objective lens would be moved within the assembly so as to cause translation of the image at the focal plane: the effect would be equivalent to scanning in the focal plane.



SYSTEM INCORPORATING THE INVENTION



OPTICS IN ONE VERSION OF THE INVENTION

The **Objective Lens Would Be Moved**, relative to the rest of the optical assembly, to scan the image in the focal plane.

The upper part of the figure depicts a generic proposed microscope-based hyperspectral imaging system incorporating the invention. The optical assembly of this system would include an objective lens (normally, a microscope objective lens) and a charge-coupled-device (CCD) camera. The objective lens would be mounted on a servomotor-driven translation stage, which would be capable of moving the lens in precisely controlled increments, relative to the camera, parallel to the focal-plane scan axis. The output of the CCD camera would be digitized and fed to a frame grabber in a computer. The computer would store the frame-grabber output for subsequent viewing and/or processing of images. The computer would contain a position-control interface board, through which it would control the servomotor.

There are several versions of the invention. An essential feature common to all versions is that the stationary optical subassembly containing the camera would also contain a spatial window, at the focal plane of the objective lens, that would pass only a selected portion of the image. In one version, the window would be a slit, the CCD would contain a one-dimensional array of pixels, and the objective lens would be moved along an axis perpendicular to the slit to spatially scan the image of the specimen in "pushbroom" fashion. The image built up by scanning in this case would be an ordinary (non-spectral) image.