Resin-Transfer-Molding of a Tool Face

Lyndon B. Johnson Space Center, Houston, Texas

A resin-transfer-molding (RTM) process has been devised for fabricating a matrix/graphite-cloth composite panel that serves as tool face for manufacturing other composite panels. Heretofore, RTM has generally been confined to resins with viscosities low enough that they can readily flow through interstices of cloth. The present process makes it possible to use a high-temperature, more-viscous resin required for the tool face. First, a release layer and then a graphite cloth are laid on a foam pattern that has the desired contour. A spring with an inside diameter of 3/8 in. (≈9.5 mm) is placed along the long dimension of the pattern to act as a conduit for the resin. Springs with an inside diameter of 1/4 in. (≈6.4 mm) are run off the larger lengthwise spring for distributing the resin over the tool face. A glass cloth is laid on top to act as breather. The whole layup is vacuum-bagged. Resin is mixed and made to flow under vacuum assistance to infiltrate the layup through the springs. The whole process takes less than a day, and the exposure of personnel to resin vapors is minimized.

This work was done by Mike Fowler of **Johnson Space Center** *and Edward Ehlers, David Brainard, and Charles Kellermann of ROTHE JV. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809.*
MSC-23104

Improved Phase-Mask Fabrication of Fiber Bragg Gratings

Wavelengths and bandwidths can be tailored over wide ranges.

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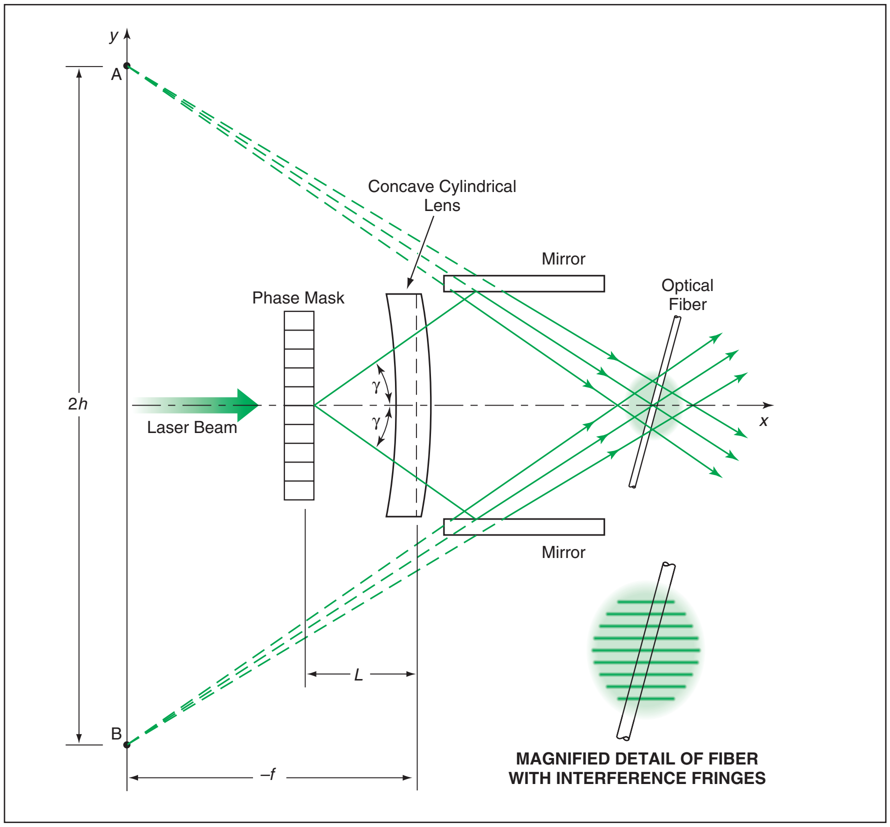
An improved method of fabrication of Bragg gratings in optical fibers combines the best features of two prior methods: one that involves the use of a phase mask and one that involves interference between the two coherent laser beams. The improved method affords flexibility for tailoring Bragg wavelengths and bandwidths over wide ranges.

A Bragg grating in an optical fiber is a periodic longitudinal variation in the index of refraction of the fiber core. The spatial period (Bragg wavelength) is chosen to obtain enhanced reflection of light of a given wavelength that would otherwise propagate relatively unimpeded along the core. Optionally, the spatial period of the index modulation can be made to vary gradually along the grating (such a grating is said to be "chirped") in order to obtain enhanced reflection across a wavelength band, the width of which is determined by the difference between the maximum and minimum Bragg wavelengths.

In the present method as in both prior methods, a Bragg grating is formed by exposing an optical fiber to an ultraviolet-light interference field. The Bragg grating coincides with the pattern of exposure of the fiber core to ultraviolet light; in other words, the Bragg grating coincides with the interference fringes. Hence, the problem of tailoring the Bragg wavelength and bandwidth is largely one of tailoring the interference pattern and the placement of the fiber in the interference pattern.

In the prior two-beam interferometric method, a single laser beam is split into two beams, which are subsequently recombined to produce an interference pattern at the location of an optical fiber. In the prior phase-mask method, a phase mask is used to diffract a laser beam mainly into two first orders, the interference between which creates the pattern to which an optical fiber is exposed. The prior two-beam interfero-



An **Optical Fiber Is Exposed** to an interference field generated by an apparatus that affords relative insensitivity to misalignment while making it possible to select the wavelength or range of wavelengths of the Bragg grating to be formed in the fiber.

metric method offers the advantage that the period of the interference pattern can be adjusted to produce gratings over a wide range of Bragg wavelengths, but offers the disadvantage that success depends on precise alignment and high mechanical stability. The prior phase-mask method affords the advantages of compactness of equipment and relative insensitivity to both misalignment and vibration, but does not afford adjustability of the Bragg wavelength.

The present method affords both the flexibility of the prior two-beam interferometric method and the compactness and stability of the prior phase-mask method. In this method (see figure), a laser beam propagating along the *x* axis is normally incident on a phase mask that lies in the (*y*,*z*) plane. The phase of light propagating through the mask is modulated with a spatial periodicity, *p*, along the *y* axis chosen to diffract the laser light primarily to first order at the angle γ. (The zero-order laser light propagating along the *x* axis can be used for alignment and thereafter suppressed during exposure of the fiber.) The diffracted light passes through a concave cylindrical lens, which converts the flat diffracted wave fronts to cylindrical ones, as though the light emanated from a line source. Then two parallel flat mirrors recombine the diffracted beams to form an interference field equivalent to that of two coherent line sources at positions A and B (virtual sources).

The interference pattern is a known function of the parameters of the apparatus and of position (*x*,*y*) in the interference field. Hence, the tilt, wavelength, and chirp of the Bragg grating can be chosen through suitable adjustments of the apparatus and/or of the position and orientation of the optical fiber. In particular, the Bragg wavelength can be adjusted by moving the fiber along the *x* axis, and the bandwidth can be modified over a wide range by changing the fiber tilt angle or by moving the phase mask and/or the fiber.

Alignment is easy because the zero-order beam defines the *x* axis. The interference is relatively stable and insensitive to the mechanical vibration because of the high symmetry and compactness of the apparatus, the fixed positions of the mirrors and lens, and the consequent fixed positions of the two virtual line sources, which are independent of the translations of the phase mask and the laser relative to the lens.

This work was done by Joseph Grant of **Marshall Space Flight Center** *and Ying Wang and Anup Sharma of Alabama Agricultural and Mechanical University.*

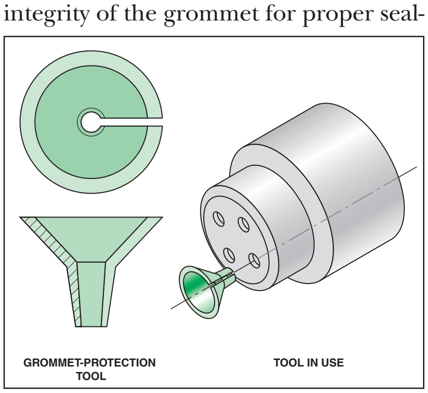
This invention is owned by NASA, and a patent application has been filed. For further information, contact Mitch Ward, MSFC Commercialization Project Lead, at mitch.ward@nasa.gov. Refer to MFS-31596.

Tool for Insertion of a Fiber-Optic Terminus in a Connector

A grommet is protected against damage.

Lyndon B. Johnson Space Center, Houston, Texas

A tool has been developed for the special purpose of inserting the terminus of an optical fiber in a cable connector that conforms to NASA Specification SSQ-21635. What prompted the development of the tool was the observation that because of some aspects of the designs of fiber-optic termini and of springs, sealing rings, and a grommet inside the shell of such a connector, there is a tendency for the grommet to become damaged and detached from the sealing rings during installation. It is necessary to ensure the integrity of the grommet for proper sealing and proper functioning of the connector. The special-purpose tool provides the needed protection for the grommet.



A **Special-Purpose Tool Resembles a Funnel,** except that it is slit along one side. It is inserted in one of the holes in the connector to protect a grommet during installation of a fiber-optic terminus in the hole.

The grommet-protection tool resembles a funnel into which an axial slit has been cut (see figure). Prior to insertion, the grommet-protection tool is rolled so that one side of the slit overlaps the other side. The rolled-up grommet-protection tool is inserted in one of the connector holes that accommodate the fiber-optic termini and is pushed in until the flange (the wider of the two conical portions) of the tool becomes seated on the connector grommet. Then a special-purpose installation tool is inserted in the flange of the grommet-protection tool and pressed in until it becomes seated in the flange. This operation expands the narrower of the two conical portions of the grommet-protection tool. The installation tool is removed and the grommet-protection tool remains expanded due to the flat surfaces on the axial slit.

By use of a standard contact-insertion tool, a fiber-optic terminus is inserted, through the grommet-protection tool, into the connector cavity. By use of a pair of forceps or needle-nose pliers, the grommet-protection tool is then pulled out of the cavity. Finally, the grommet-protection tool is removed from around the installed fiber-optic cable by pulling the cable through the axial slit.

Unlike in some prior procedures for installing the fiber-optic termini in the connector, the procedure that involves the use of the present grommet-protection tool does not include the use of lubricants that can contaminate the interior of the connector. The grommet-protection tool is made of a fluoropolymer, taking advantage of the flexibility of such polymers and further taking advantage of the inherent slipperiness of fluoropolymers. Although the tool is designed primarily for insertion of a fiber-optic terminus, it might also be useful for extracting a previously installed fiber-optic terminus.

This work was done by Wes King, Donald J. Domonoske, John Krier, and John White of Boeing North American, Inc. for **Johnson Space Center**. *For further information, contact*

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