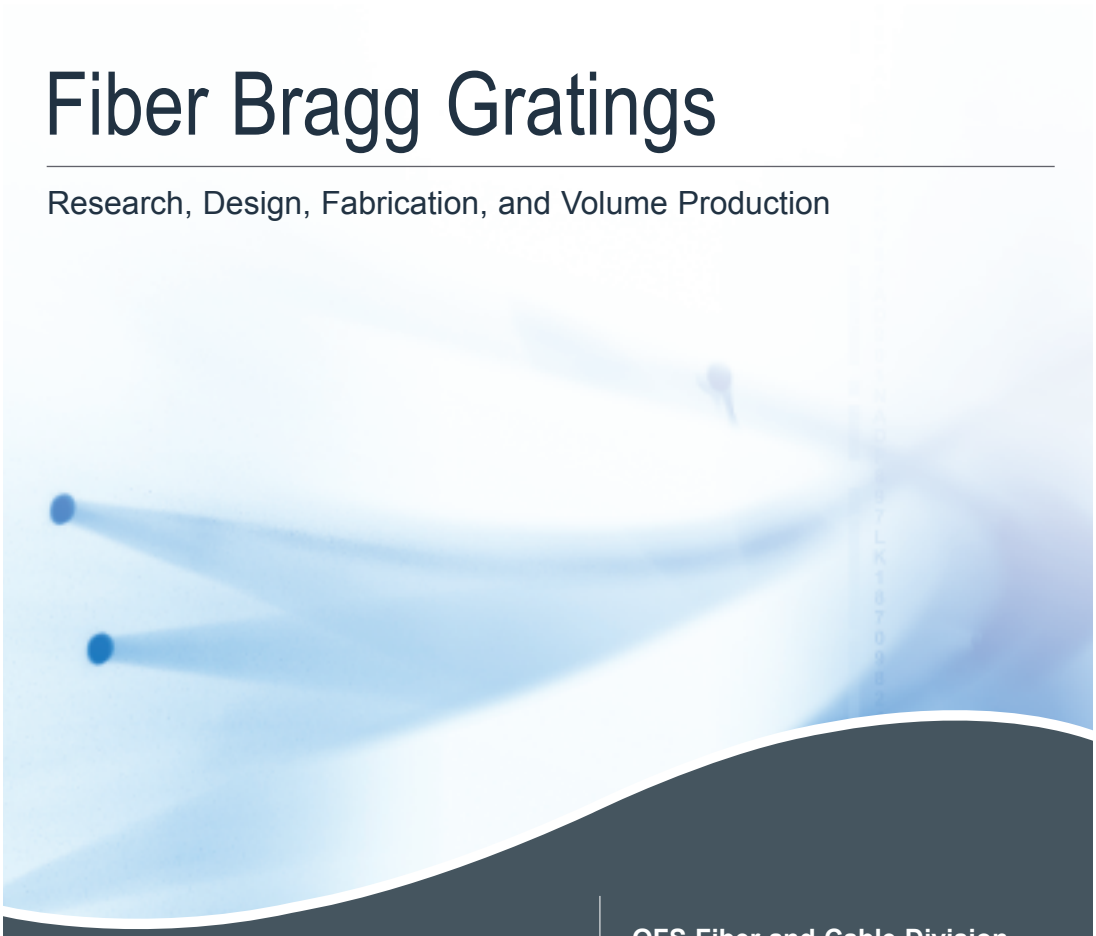
ofs
A Furukawa Company

Your Optical Fiber Solutions Partner™

Fiber Bragg Gratings

Research, Design, Fabrication, and Volume Production

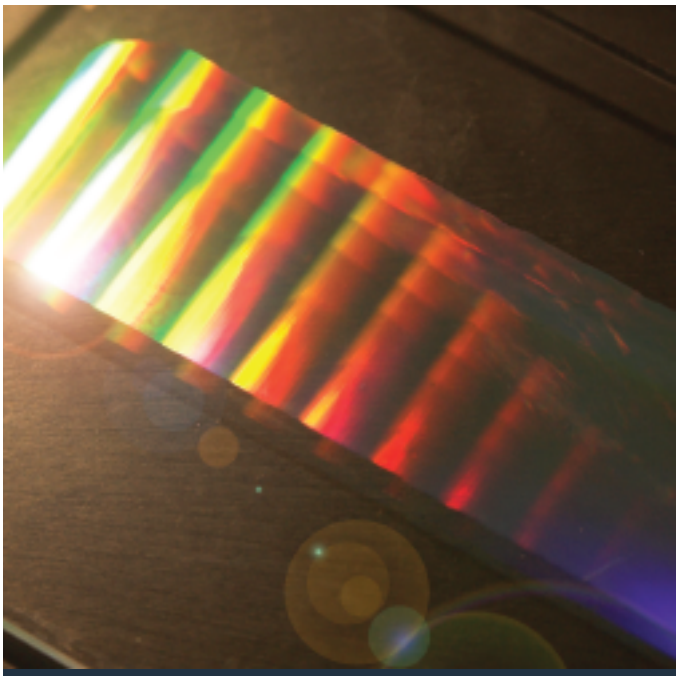


All capabilities within one company

OFS Fiber and Cable Division

OFS Specialty Photonics Division

OFS Labs



A grating is made by exposing a section of the fiber to UV light through a phase mask, creating an interference pattern of maxima and minima.

OFS Bragg Gratings

OFS Specialty Photonics is a leading manufacturer of specialty optical fibers and fiber-based devices. Gratings are one of the tools, along with novel fiber designs, used to manipulate the behavior of light within optical fibers and devices. For 10 years fiber Bragg gratings have been a focus of our scientists' R&D and have become an integral part of OFS devices such as fiber lasers, tunable dispersion compensators and optical channel monitors[1]. OFS is now making our state–of-the-art gratings commercially available. We can provide fiber, gratings and specialty coatings optimized for the device and environment defined. Who better to achieve the grating performance you have in mind?

Intellectual Property

Our expertise is an outgrowth of the innovative and broad spectrum of photonics-related R&D conducted at OFS Labs, and prior to 2000, Bell Labs. OFS holds a portfolio of over 600 optics-related patents, including 59 gratings-related patents. The gratings portfolio represents a path of unparalleled gratings development from fundamental technology that enabled the broad use of gratings to current state-of-the-art technology that has yet to be used commercially. Our fundamental patents include those relating to hydrogen and deuterium loading, temperature annealing of gratings, and write-through coatings.

Advantages

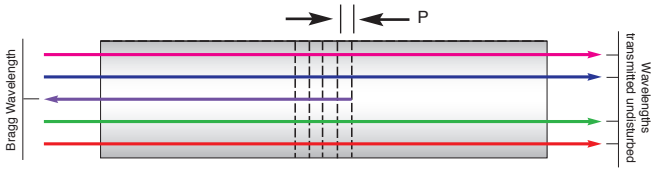
- Bragg gratings are passive devices that are an integral part of an optical fiber. They enable the design of more complex "all-fiber" devices.
- Gratings can effectively replace bulk optics or thin film filters for smaller package size.
- Compatible with other optical fibers, gratings can be spliced into a device with low insertion loss.

Gratings Basics

Germanium, a dopant used in many optical fiber cores is photosensitive to UV light. A grating is a selective wavelength filter in the core of an optical fiber that is used to measure strain or temperature. It is made by exposing a section of the fiber to UV light through a phase mask. An interference pattern of maxima and minima is formed causing a permanent periodic change to the index of the core. A small amount of light is reflected at each index variation. At the "center wavelength" or "Bragg wavelength," all the reflections add coherently.

`ÉåíÉê= t~îÉäÉåÖíÜ = *O÷å÷m*

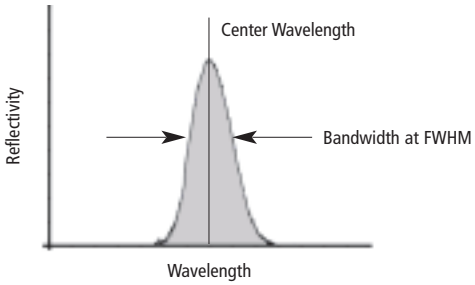
where *å* is the effective (average) index change and *m* is the period or distance between index variations in the grating.

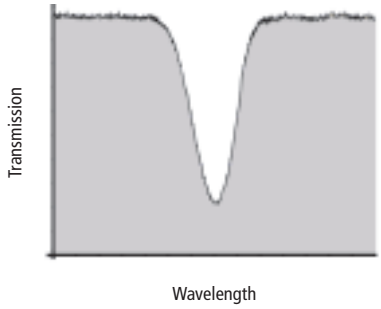


Index changes in the core of the fiber shown as dotted lines

_~åÇ ï áÇíÜ is a measure of the reflected signals spectral width. It is usually measured at Full Width Half Max (FWHM).

oÉÑäÉÅíáîáíó is the percentage of light reflected at the Bragg Wavelength and can be a few percent or as high as 99.9%.





The wavelengths outside of the reflected bandwidth are transmitted undisturbed.

Fabrication

- Unless a write-through coating is used, the acrylate coating on the fiber must be first stripped and then re-applied after grating fabrication.
- The fiber is loaded with diffuse deuterium (termed "hydrogen loading") before the gratings are written, to increase the photosensitivity of the fiber.
- The grating is fabricated by exposure to UV light at 248 nm which passes through a phase mask, creating an interference pattern of fringes in the optical fiber. A holographic method can also be used.
- After exposure to the UV, the fiber is pre-annealed to stabilize the index changes that have taken place.

Manufacturing Capabilities

Gratings Basics

OFS fibers can be manufactured on-site using proprietary write-through acrylate coating. Grating manufacture is simplified because the strip and recoat steps normally performed before and after grating writing are not needed. This means less handling and improved fiber reliability.

Grating Types —

OFS Specialty Photonics Division will manufacture your prototype or production-volume Bragg gratings to your precise specifications. Below is an overview of OFS manufacturing capabilities.

- **Stabilizer Gratings -** Laser Stabilization Gratings are low reflectance gratings written in a pump laser pigtail. The narrow spectrum of the feedback locks the laser output, causing it to emit at the grating's center wavelength. Additionally, high frequency noise is minimized.

Specifications:

Center Wavelength: 980, 1480 nm
Reflectivity: 2% to 20%
Bandwidth: 0.5 to 2.0 nm FWHM

- **High Reflector Gratings -** These gratings are used to reflect a high percentage (>99%) of light at a specific wavelength. They have application in pump lasers, laser cavities and selective filtering of channels in lightwave systems.

Specifications:

Center Wavelength: 980, 1060, 1480, 1550 nm
Reflectivity: >99%
Bandwidth: 0.4 to 2.0 nm FWHM

- **Wide Band Gratings -** Utilize a grating writing technique termed "chirping" to achieve a wide band of reflected light. Actually a combination of one or more individual gratings written together, the slope of the grating edge can be modified to meet your requirements. Wide band filters have application in DWDM systems, gyros and sensors.

Specifications:

Center Wavelength: 980 to 1600 nm
Reflectivity: >95%
Bandwidth: 1 to 20 nm FWHM

- **Fiber Arrays –** Fiber arrays are multiple gratings written in a single length of fiber. The resulting strings of gratings have application in military acoustic sensors, seismic sensors, strain and structural sensors. OFS proprietary write-through acrylate coating simplifies the process by eliminating the need for multiple strip and recoat sections. OFS has advanced capabilities for acoustic sensor gratings written at multiple wavelengths.

- **Bragg Gratings in Polyimide Coated Fiber –** OFS PYROCOAT™ Polyimide coating enables the use of optical fibers in harsh environments. Polyimide is a heat-resistant polymer that performs to 300°C and has high strength, abrasion- and chemical-resistance. Applied to a thickness of only 15 µm, the result is a small form factor fiber of 155 µm diameter.

  OFS now offers fiber Bragg gratings in polyimide coated fiber. Extending our gratings technology to include polyimide coated fibers will benefit applications such as oil and gas sensing, structural sensing, industrial processing or avionics sensing.

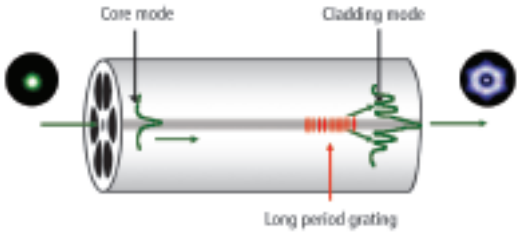
Next Generation Products

Available now from OFS Labs:

OFS Labs is a world leader in scientific and technical innovation in optical fiber and photonic devices. Gratings development continues to be a key focus of OFS Labs R&D. The three OFS Specialty manufacturing sites work closely with OFS Labs in bringing new products from lab prototypes to full production. Talk to us about your requirements and we may be able to provide a novel fiber/grating combination that will exceed your performance expectations. OFS Labs has expertise in the following types of gratings: chirped, long period, multimode, higher order mode and thermally tunable.

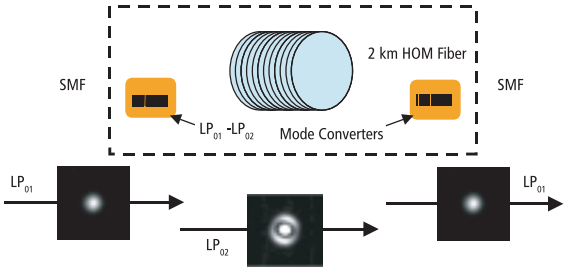
- **Sensing with LPGs in Dispersion Engineered Fiber –** Long Period Gratings (LPGs) couple light from the propagating mode forward into guided cladding modes where they are quickly attenuated. LPGs written in Dispersion Engineered Fiber provide the platform for a range of sensors that measure one of the following: ambient material index, temperature or strain. This fiber/grating combination represents a radical change in the measurement technique required to deploy LPG technology. This change translates to big savings in the cost of sensor deployment because, unlike conventional LPG's that require expensive apparatus to measure spectral response these sensors measure amplitude modulation and can be designed with only an LED and power meter. Order of magnitude higher sensitivity and resistance to contaminants in the environment are additional features of this technology.

- **Sensing with LPGs in Microstructure Fiber –** In the OFS Grapefruit Microstructure Fiber, the lower order modes are confined by the airholes and are insensitive to surrounding media. After the addition of LPG's the higher order modes interact with the holes and with the material they may be infused with.



- Grapefruit Microstructure Fiber with long period gratings

Dispersion Compensation – Long period gratings are excellent mode-converters that transform the guided core mode to a higher order mode guided in the cladding. Higher order modes offer more freedom in controlling dispersion because they have higher slope, less curvature in the dispersion slope and higher effective area. This allows shorter fiber lengths, lower losses, and increased Optical Signal to Noise Ratio (OSNR), as well as better system design. Mode converter gratings are used in pairs since a second grating converts the higher order mode back to a core guided mode after dispersion has been modified.



Dispersion Compensating Module uses dispersion properties of higher order modes, (HOM).

Custom Products

Fiber Bragg Gratings Worksheet

ofs
A Furukawa Company

An online version of this worksheet is available at **www.SpecialtyPhotonics.com**

Custom Grating Worksheet

Use this worksheet to specify a custom fiber Bragg grating or array. When you have made your specifications, please fax this worksheet to: (860) 674-8818. A representative will call to discuss your gratings requirements.

Optical Parameters

Fiber type required _____

Center Wavelength:

_____ nm with ± tolerance of

_____ nm

Bandwidth:

_____ nm with ± tolerance of

_____ nm

@ level: transmission _____dB

Reflection _____dB

% Reflectivity Value: _____

Peak _____

Minimum _____

Average _____

Crosstalk requirements on reflection

_____ dB @ _____ nm

Maximum insertion loss per grating

_____ dB

Maximum loss per array

_____ dB

Measurement Wavelength _____ nm

Dimensional Parameters

Length of grating _____ mm with

_____± tolerance of _____ mm

_____

Maximum Recoat Outer Diameter _____ µm _____

with _____ ± tolerance of _____ µm

Maximum Recoat Length _____ mm with

_____± tolerance of _____ mm

Positional Dimensions
of Gratings and Tolerance:

Testing Parameters and Packaging Requirements

Proof Test Level for Individual Gratings

_____ & Final Array _____ kpsi

Test Data to be Provided:

Marking Requirements:

When you have made your specifications and completed your contact information below, please **Fax** this worksheet to:
1-860-674-8818

Name: _____

Title: _____

Company: _____

Address: _____

_____

Phone: _____

Email: _____

[1] Optical Channel Monitors are no longer available from OFS but may be purchased directly from Princeton Lighwave Inc., Princeton, NJ, USA.

This document is for informational purposes only and is not intended to modify or supplement any OFS warranties or specifications relating to any of its products and services. Drawings are not to scale. OFS reserves the right to make changes at any time, without notice, to the products and specifications described in this document.

OFS products described herein may be subject to the U.S. Export Administration Regulations and may require approval from the U.S. Department of Commerce, Bureau of Industry & Security, prior to export.

Copyright © 2013 OFS FITEL, LLC.

All Rights Reserved.

PYROCOAT is a trademark of OFS FITEL, LLC.

0313

ofs
A Furukawa Company

55 Darling Drive
Avon, CT 06001

Phone: **1 860 678 0371**
Toll Free: **1 888 438 9936**
Email: **Info@SpecialtyPhotonics.com**
Web: **www.SpecialtyPhotonics.com**

/ofsoptics
/company/ofs
/ofs_optics
/OFSoptics

AWEA Business Member
SPIE
OSA Corporate Associate Member
ODVA
MDMA