

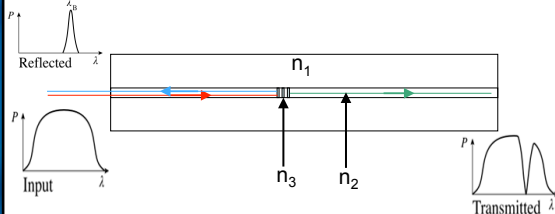
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FIBER BRAGG GRATING SENSOR

The elementary fiber Bragg grating (FBG) comprises a short section of optical fiber in which the core refractive index is modulated periodically by exposure to UV light.



$$\lambda_B = 2n_{eff}\Lambda$$

λ_B : Bragg wavelength

n_{eff} : effective refractive index of the guided mode in the fiber

Λ : period of the refraction index modulation.

$$\frac{\Delta\lambda_B}{\lambda} = C_S\varepsilon + C_T\Delta T$$

(Sensing principle)

ε : strain

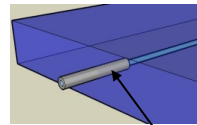
T : temperature

C_S : coefficient for strain

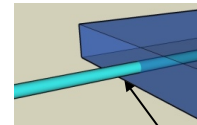
C_T : coefficient for temperature

MOTIVATION: INGRESS/EGRESS ISSUE

Conventional coupling to embedded FBG sensors is either bulky or fragile.



embedded ferrule



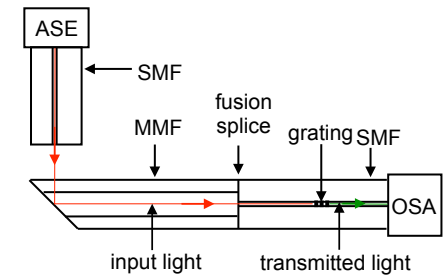
trailing fiber

- ◆ Embedded connectors
 - Connectors (e.g. ferrules) embedded in composite structures
 - Bulky and requires side egress

- ◆ Trailing fibers
 - Fibers enter/exit at ingress/egress points
 - Very fragile

APPROACH: FREE SPACE COUPLING

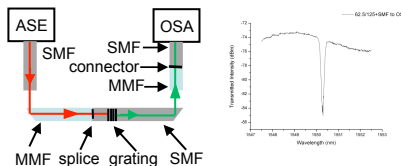
Fusion splice 62.5/125 multi-mode fiber (MMF) to single-mode FBG sensor, then integrate 45-degree mirror onto MMF to enable free-space coupling in the surface normal direction.



ASE: amplified spontaneous emission light source
OSA: optical spectrum analyzer

UNEMBEDDED MMF/FBG

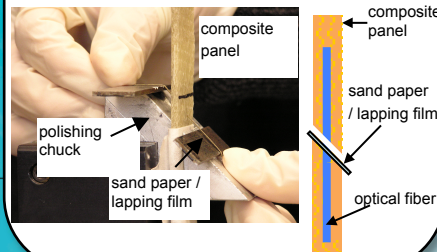
Both the MMF and SMF were polished to 45-degree by 600 grit sand paper and 12.5 μm aluminum oxide slurries.



Simultaneous free space coupling into and out of un-embedded FBG sensor is achieved.

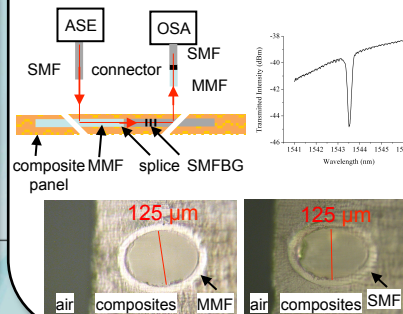
MANUAL POLISHING OF EMBEDDED OPTICAL FIBER

We have developed a minimally-invasive hand polishing technique to integrate 45-degree mirror surfaces onto the MMF and SMF embedded in a composite material.



EMBEDDED MMF/FBG

With the hand polished mirrors, we have achieved high efficiency non-contact coupling of embedded FBG sensors.



CONCLUSIONS

- ◆ First ever demonstrated non-contact interrogation of FBG sensors at both input and output.
- ◆ More robust and less bulky than conventional coupling.
- ◆ This coupling technique will be especially useful for research in the field of smart structures.

ACKNOWLEDGEMENTS

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