# Fiber Sensors + Textiles = Smart Textiles?

*Dr. Eric Lindner, CEO*
*FBGS Technologies GmbH*

FBGS
DRAW TOWER GRATINGS

# Outline

- Introduction
- Fiber Bragg Grating (FBG) Sensors
- Textile integration
- Applications
- Outlook & Conclusion

FBGS
DRAW TOWER GRATINGS

# Who and where we are?

FBGS is a Germany/Belgium based company which develops, fabricates and commercializes Fiber Bragg Grating (FBG) sensors, measurement devices and tailored sensing solutions for customers in many markets.

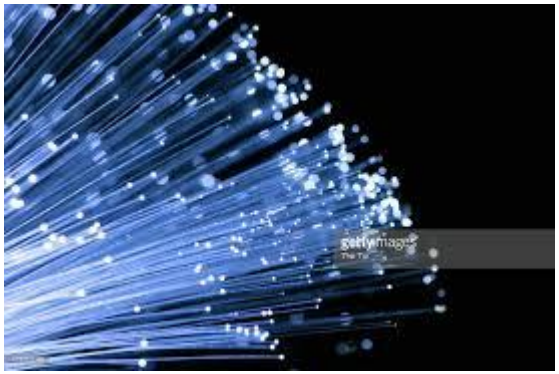
MEDICAL | OIL & GAS | TELECOM | AEROSPACE | INDUSTRY | ENERGY

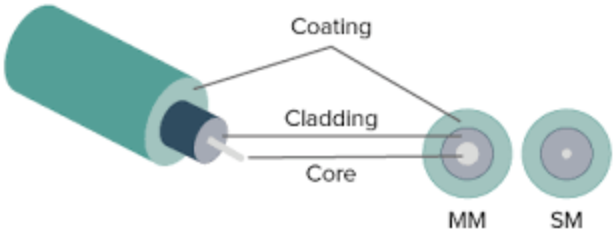

**FBGS** is member of the TOF alliance and works together with the project partners to develop the next generation of fiber optic sensors for the measurement of force and shape.

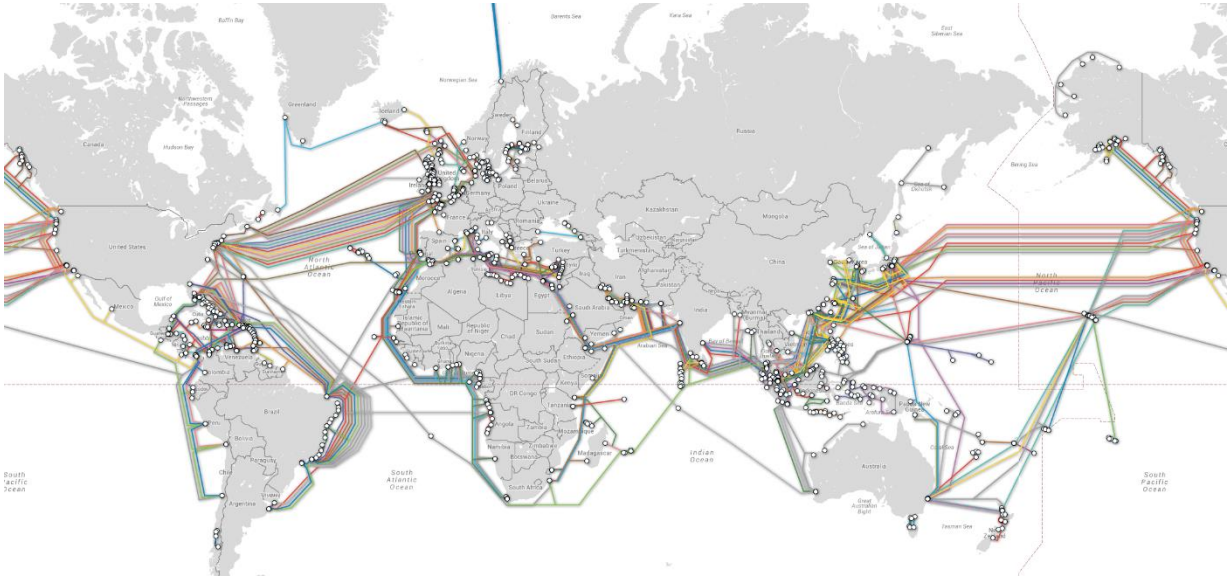
FBGS
DRAW TOWER GRATINGS

# Optical Fibers

- Optical fibers are the backbone of todays internet communication
- Corning celebrated this year 1 Billion km fiber delivered (total in the world ~4 Billion km)
- = 100.000 times earth or circumference or 26 times earth- sun distance
- Well established and affordable high tech (today ~ few €/km)
- Fibers can do more than telecommunication and are also useful for sensing





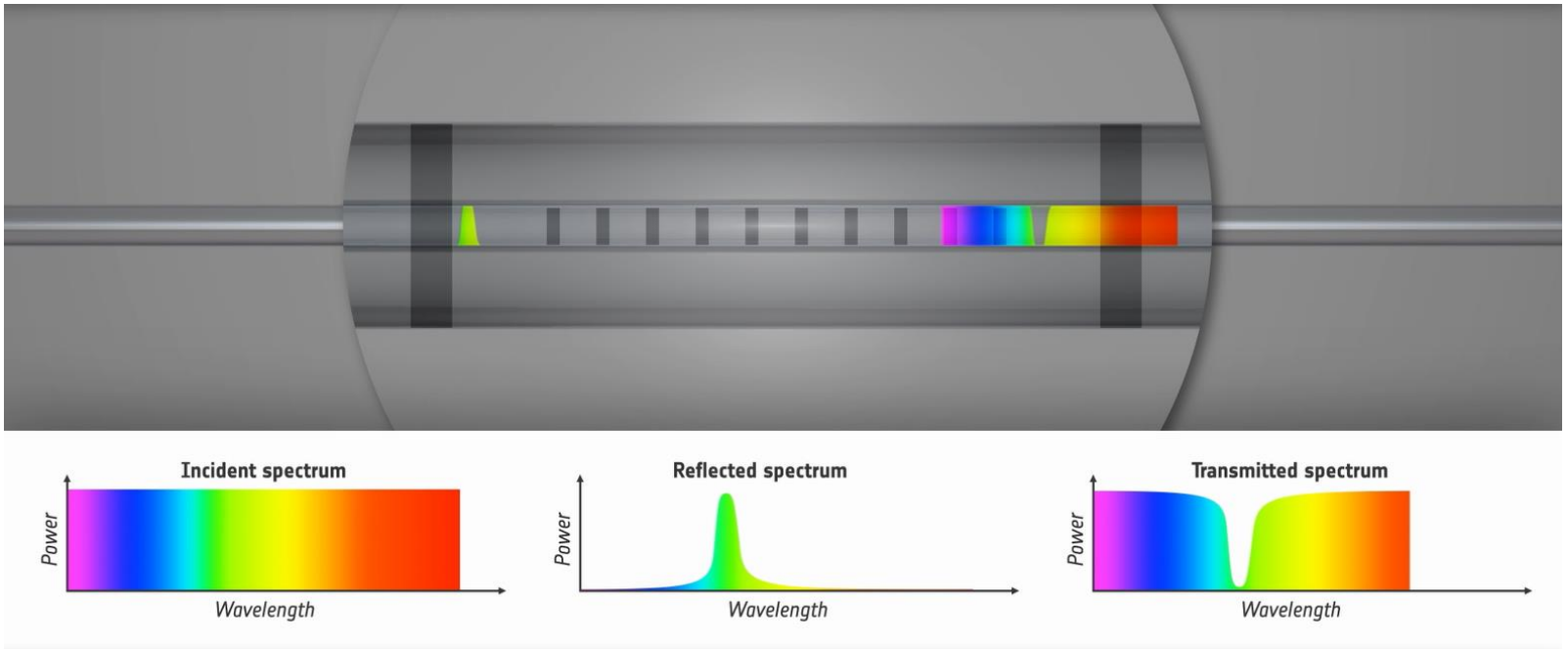
FBGS
DRAW TOWER GRATINGS

# Outline

- Introduction
- Fiber Bragg Grating (FBG) Sensors
- Textile integration
- Applications
- Outlook & Conclusion

FBGS
DRAW TOWER GRATINGS

# FBG response

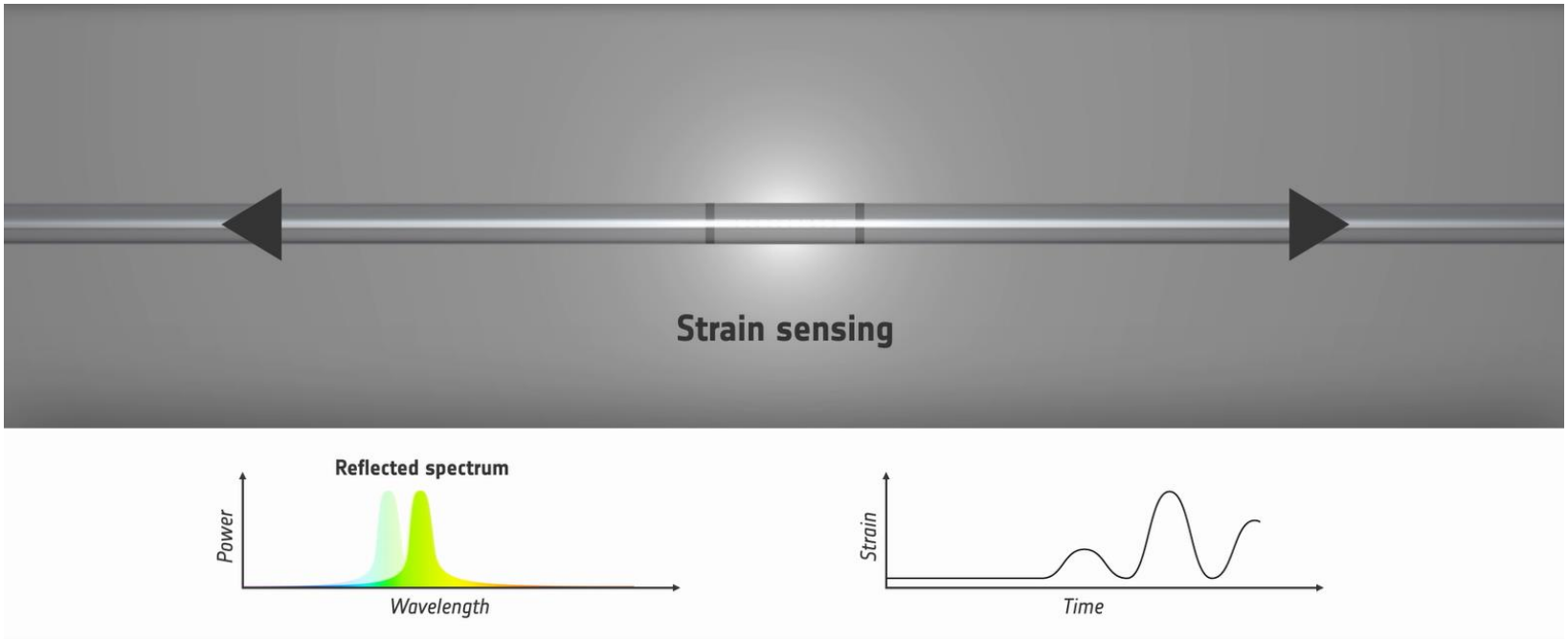



**The reflection and transmission properties of a Fiber Bragg Grating.**

***BRAGG CONDITION:*** $\lambda_B = 2\,n\,\Lambda$

FBGS
DRAW TOWER GRATINGS

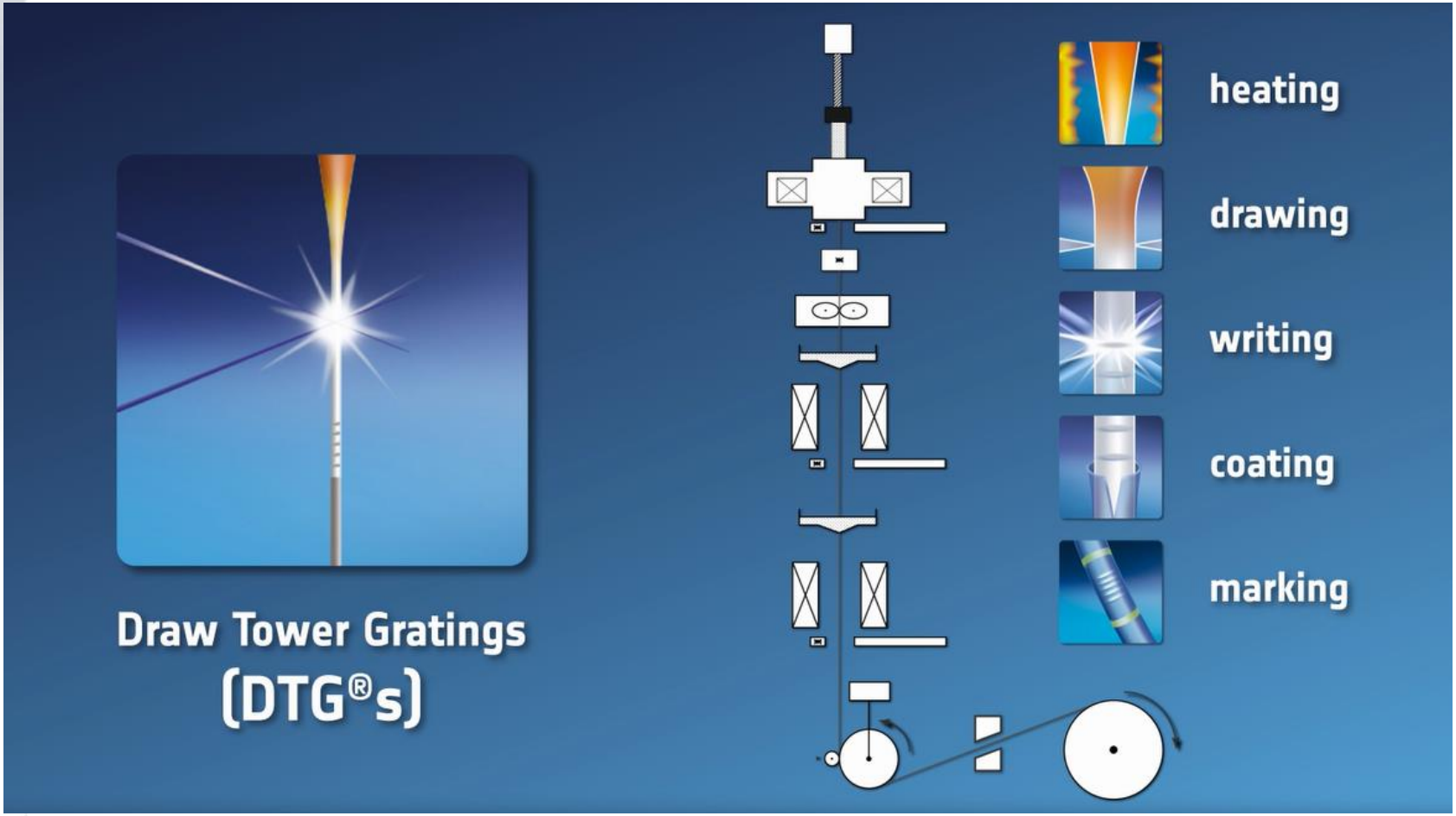
# FBG as sensor




$$\lambda_{Bragg} = 2n\Lambda \xrightarrow{\text{Strain}} \lambda'_{Bragg} = 2n'\Lambda'$$

FBGS
DRAW TOWER GRATINGS

# DTG® Process




FBGS
DRAW TOWER GRATINGS

# Advantages of FBG sensing

## Advantages

### Reliability

- Passive component
- Long life time (>20 years)
- No corrosion
- Stable over time (No calibration required)
- Cables and connectors are telecom grade

### Performance

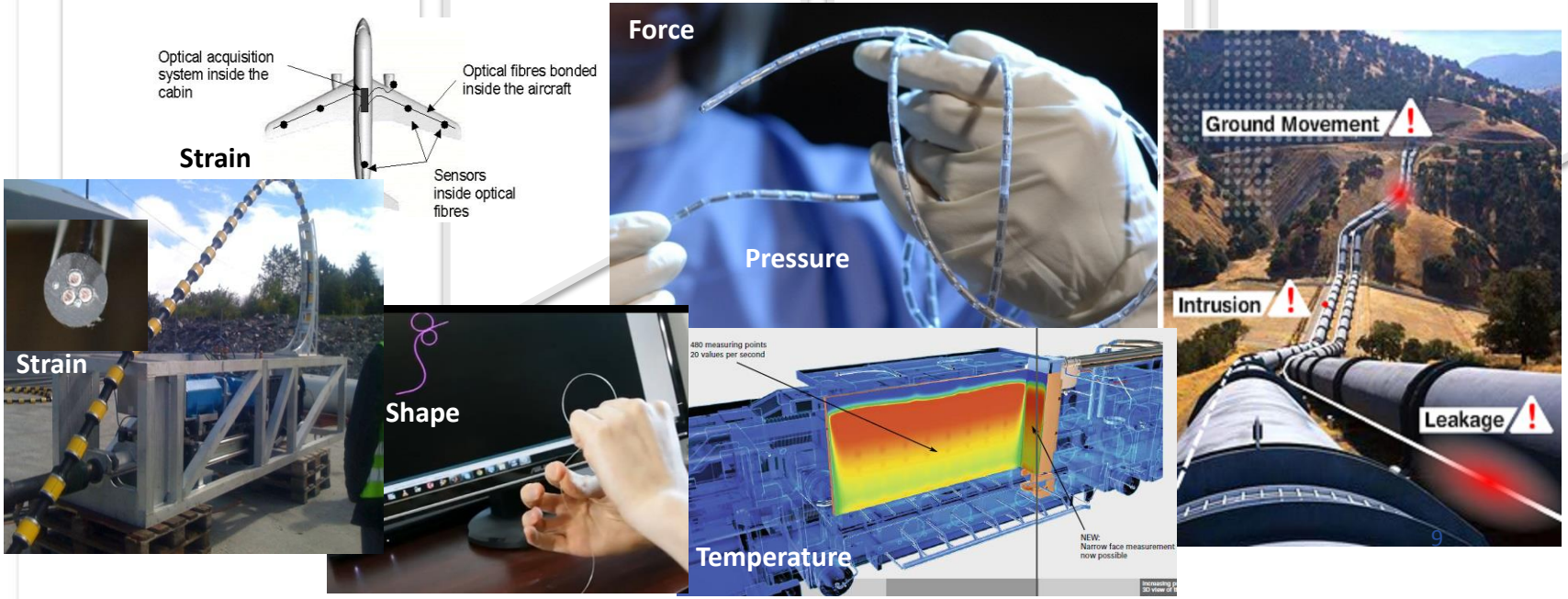
- 40 or more sensors in 1 fiber
- Less cables
- Easy installation
- High fatigue resistance
- Long distance measurements (20+ km)

### Measurement based on light

- Immune to electro-magnetic radiation & radio frequency interference
- Immune to high voltage discharge
- Explosion safe

### Small size

- Fiber is also the sensor
- Lightweight & small diameter (< ¼ mm)
- High integration and embedding capabilities




FBGS
DRAW TOWER GRATINGS

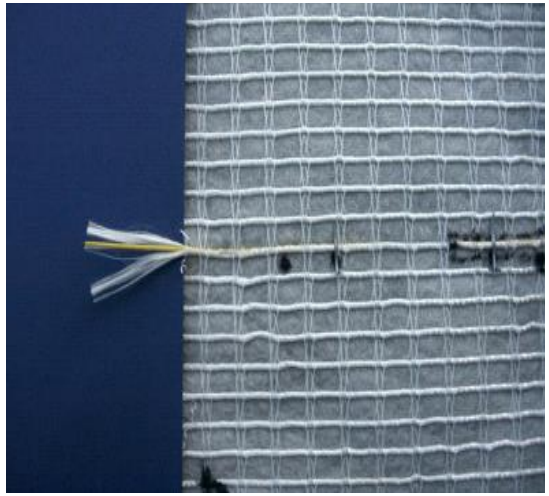
# Outline

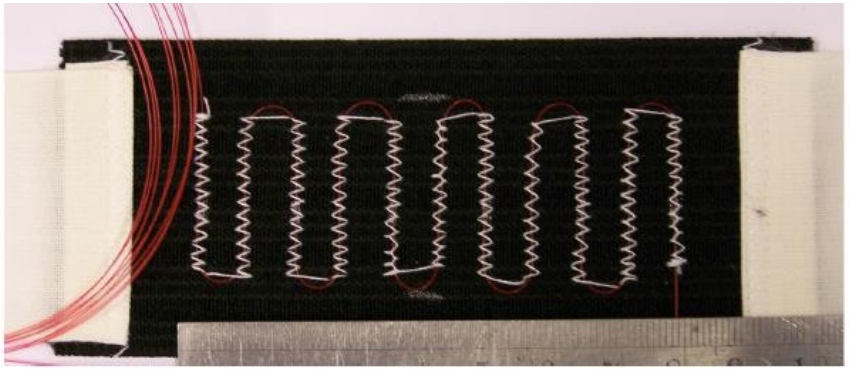
- Introduction
- Fiber Bragg Grating (FBG) Sensors
- Textile integration
- Applications
- Outlook & Conclusion

FBGS
DRAW TOWER GRATINGS

# How to combine glass and textiles?

- Idea to use adapted established productions processes (stitching, weaving, knitting etc.) and combine this with optical fibers
- Requirement: robust and flexible optical sensing fiber with customized sensing sections (→ FBGS)

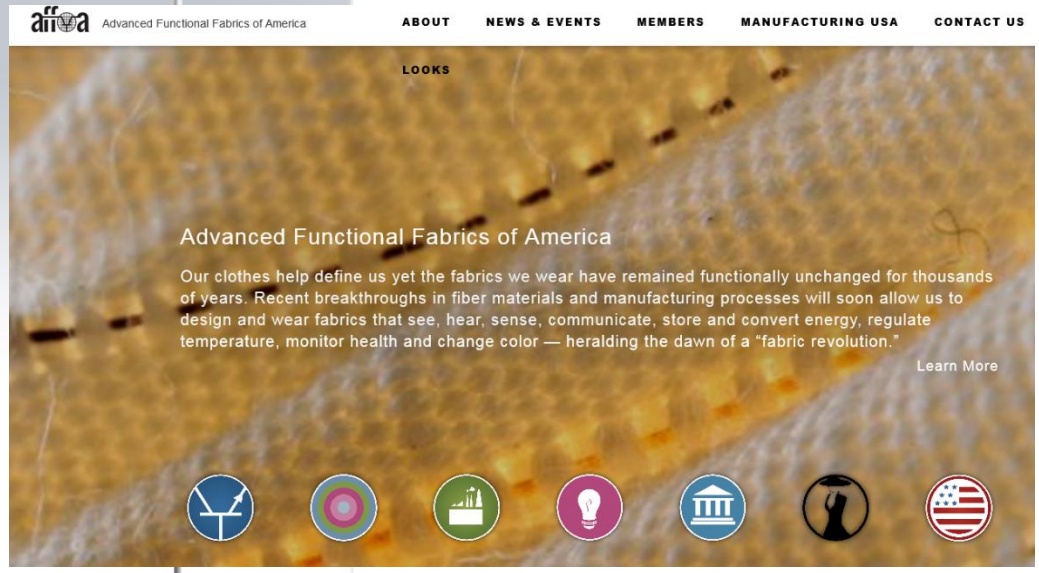





FBGS
DRAW TOWER GRATINGS

# AFFOA Initiative

- AFFOA intitiative is a consortium to enable advanced fabrics with the integration of optical fibers and electronics into textiles (www.affoa.org)
- Consortium of companies and Universities lead by the MIT
- Funded with 300 M USD in 5 years





FBGS
DRAW TOWER GRATINGS

https://www.youtube.com/watch?v=_oDf9VNcVZ0

# Outline

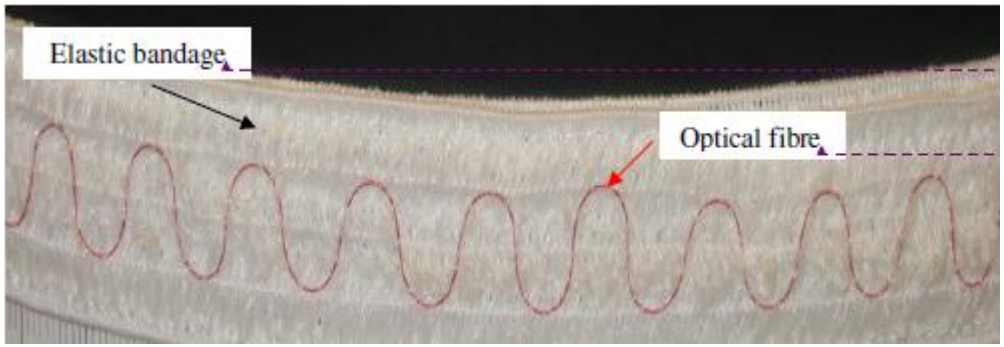
- Introduction
- Fiber Bragg Grating (FBG) Sensors
- Textile integration
- Applications
- Outlook & Conclusion

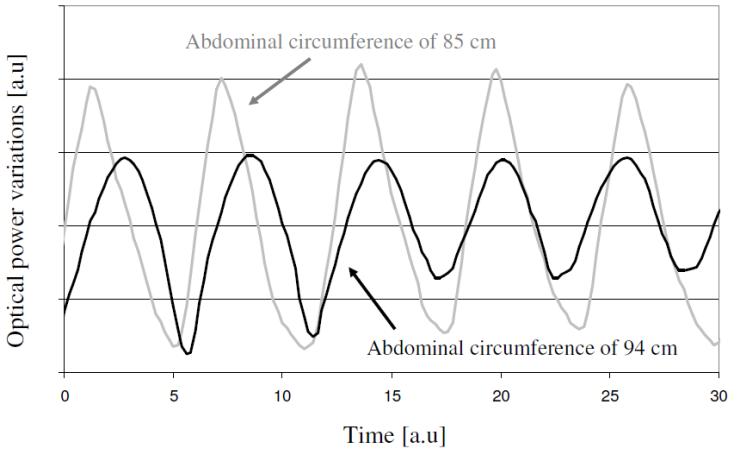
FBGS
DRAW TOWER GRATINGS

# Applications

Smart Bandage

- Smart bandage for different application
- Respiratory movement
- Hearth beat etc.
- Intensity based sensors in this case based on plastic fibers
- Same principle applicable to glass fibers



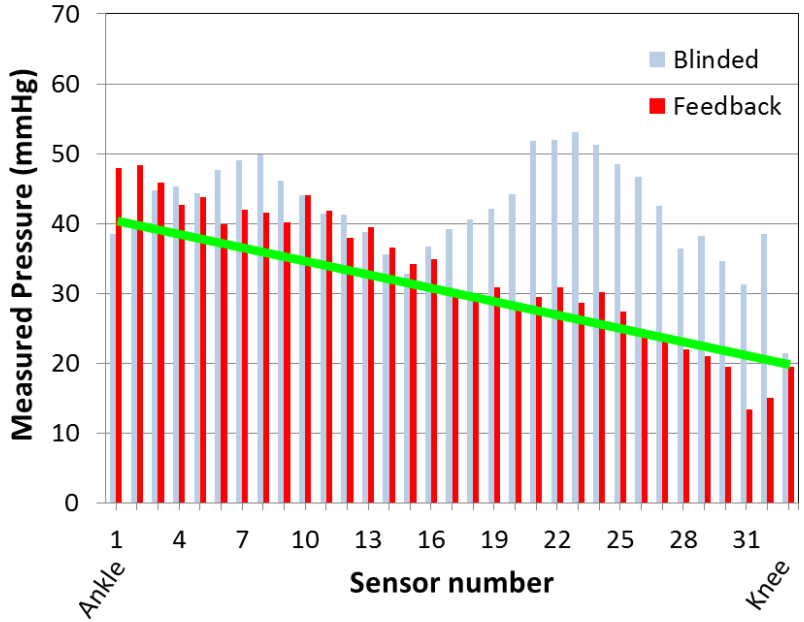

BAM
Bundesanstalt für Materialforschung und -prüfung

FBGS
DRAW TOWER GRATINGS

# Applications

Smart Bandage 2

- Measurement of compression under a bandage
- Important to have uniform pressure for compression therapy
- Tape sensor under the bandage is measuring the pressure on 33 point between the knee and the ankle

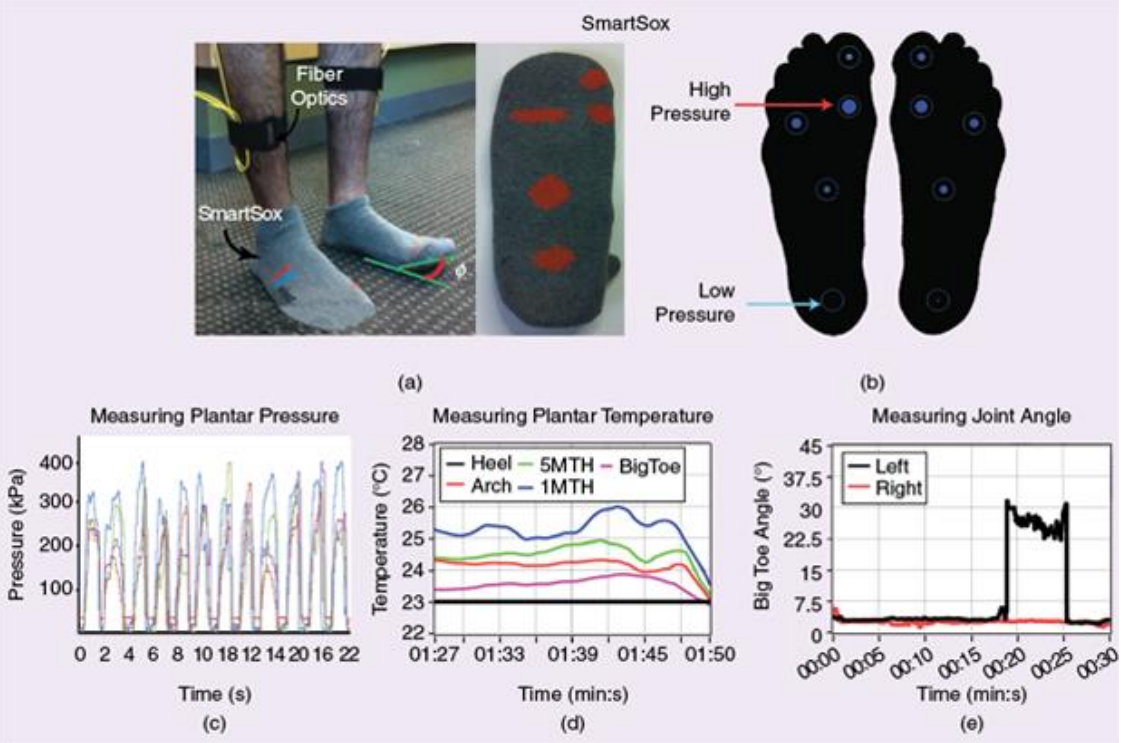



FBGS
DRAW TOWER GRATINGS

# Applications

Smart Sox

- Measurement of pressure in smart sox for diabetes patients
- People lose sensation for pain and tend to form ulcers in the foot
- Fiber optic (FBG based pressure sensor) embedded in the sox for a pressure mapping of the foot
- Alarm the doctor in the case of high pressure as the risk of ulcers




http://www.foxbusiness.com/features/2014/06/02/wearable-technology-saving-limbs-diabetes-patients.html

FBGS
DRAW TOWER GRATINGS

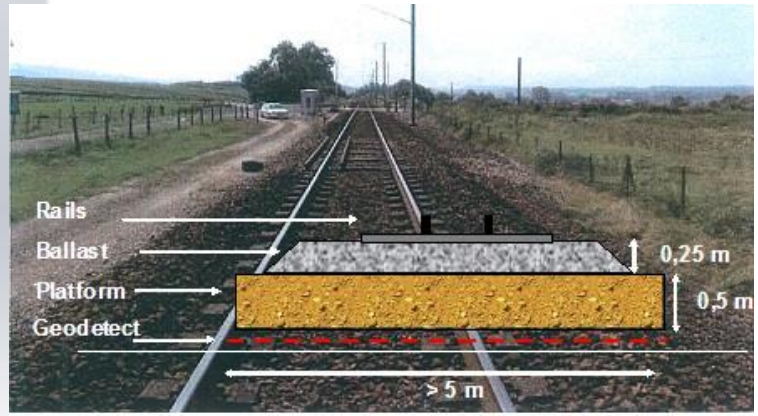
# Applications

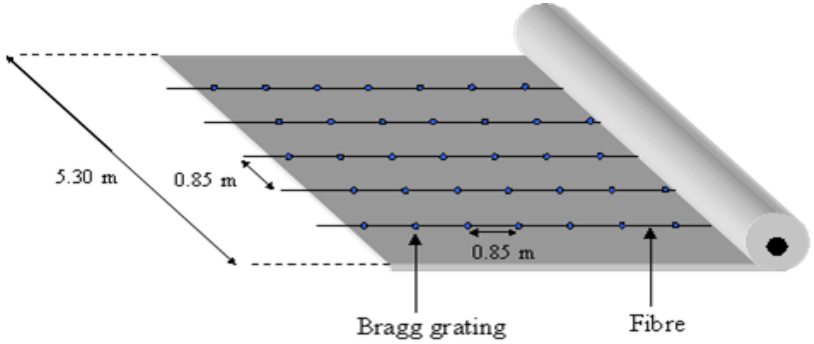
## Geotextiles

FBGS
DRAW TOWER GRATINGS

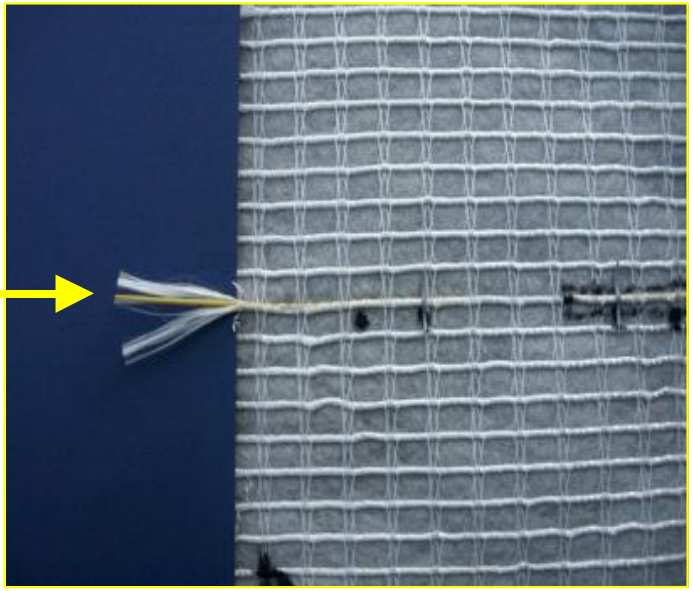
# Applications

## Geotextiles




## GEODETECT



## Surveillance of underground structures

## Geotextile + High Strength Optical Fiber

FBGS
DRAW TOWER GRATINGS

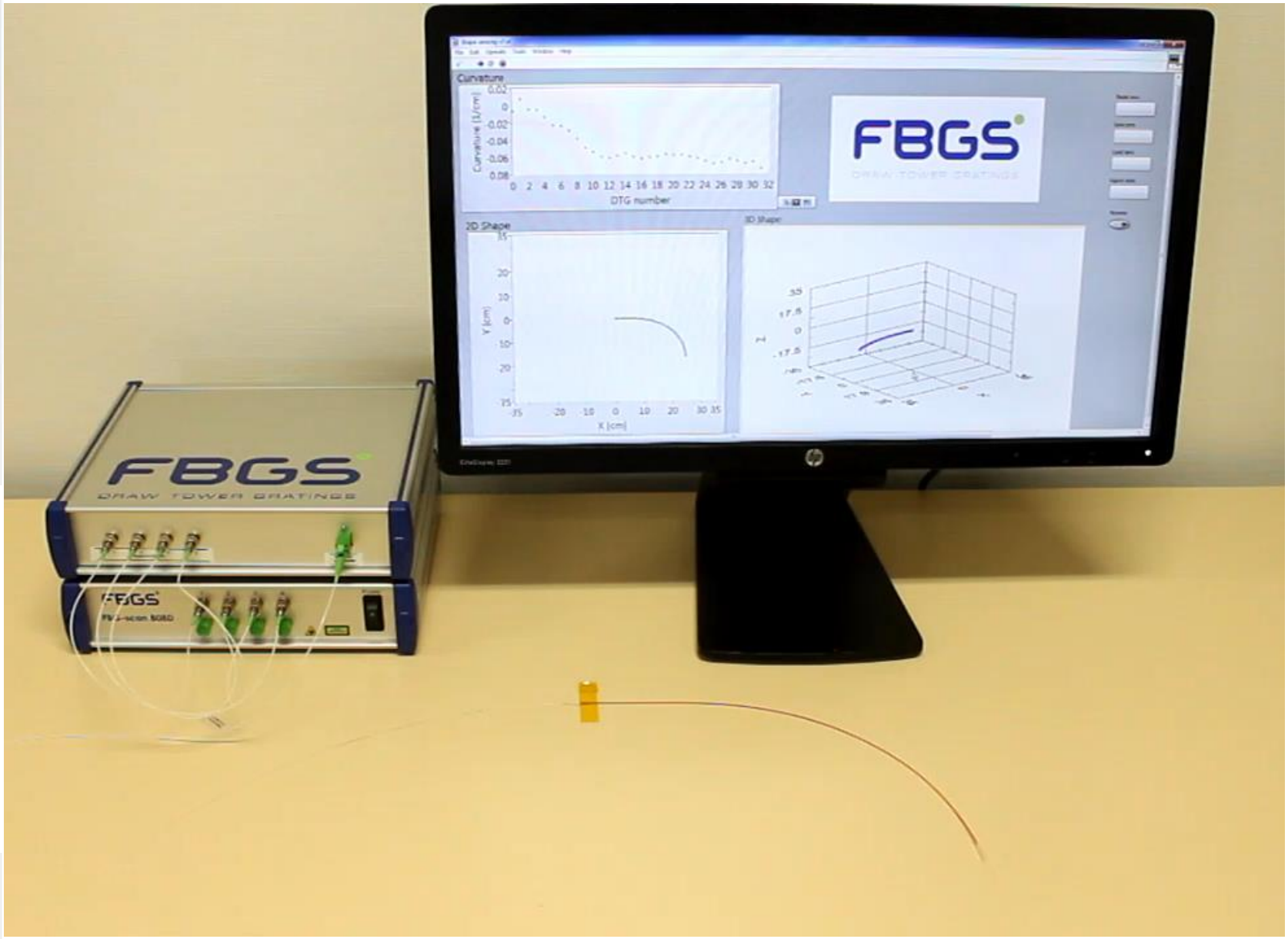
TENCATE
materials that make a difference

# Outline

- Introduction
- Fiber Bragg Grating (FBG) Sensors
- Textile integration
- Applications
- Outlook & Conclusion

FBGS
DRAW TOWER GRATINGS

# Fiber Optic Shape sensing Outlook




FBGS
DRAW TOWER GRATINGS

TOF TAILORED OPTICAL FIBERS

# TOF Alliance


Dr. Eric Lindner
Speaker TOF



GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung

WACHSTUMSKERNE
UNTERNEHMEN REGION
Die BMBF-Innovationsinitiative Neue Länder

# TAILORED OPTICAL FIBERS · TOF · CONSORTIUM

**18 companies and 3 research institutes**

form the Innovative Regional Growth Core **>Tailored Optical Fibers< [TOF]** and will develop a joint and unique **technology platform** for tailor-made specialty optical fibers for new photonic applications over the next three years.

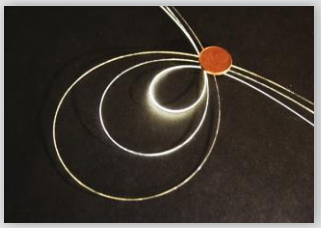
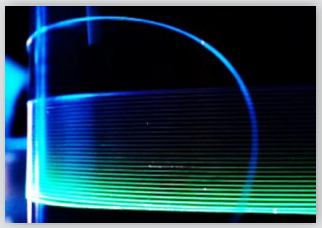
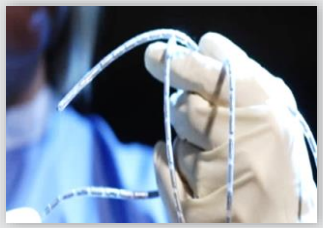
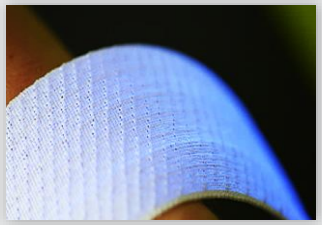
WACHSTUMSKERNE UNTERNEHMEN REGION
Die BMBF-Innovationsinitiative Neue Länder

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

# REGION OF THE ALLIANCE


- Glass material producers
- Fiber Producers
- FBG Producer
- Fiber Component Producers
- Laser System Producers
- Sensor System Producers
- Textile Manufacturers
- System Integrators

# RESEARCH PROJECTS

| VP 1 | VP 2 | VP 3 | VP 4 |
|---|---|---|---|
| **Robust technical fibers** | **Fiber-based light sources** | **Fiber-based sensor systems** | **Illuminating fiber-based fabrics** |
|  |  |  |  |
| New materials and technologies for reproducible/industrial production of optical fibers based on silica glass. | Innovative light sources based on novel micro structured and nanostructured fibers. | New sensor concepts based on micro structured fibers and hollow core fibers for different applications. | Processability and use of glass-based optical fibers in textile products. |

# Office

**Tailored Optical Fibers**
c/o OptoNet e.V.

Leutragraben 1

07743 Jena

T: +49 (0) 36 41 / 573 36 54
F: +49 (0) 36 41 / 573 36 59

info@tailored-optical-fibers.net
www.tailored-optical-fibers.net

# Conclusion

- Fiber Optic sensing  and textiles can for sure have a combined future for creating smart textiles
- Development will be first driven by high end applications (medical, safety, asset monitoring)
- Challenges:
  - Textile Integration
  - Costs of the technology
  - Reliability (washing, drying etc.)
  - Combination with electronics

**Fiber Sensors + Textiles = Smart Textiles**

FBGS
DRAW TOWER GRATINGS

# Thank you for your attention!

FBGS Technologies GmbH
Winzerlaer Str. 2
07745 Jena
+493641508514
info@fbgs.com

www.fbgs.com

FBGS
DRAW TOWER GRATINGS