

Ground Testing of Satellite Structures using Optical PM-FBG Sensors to Simultaneously Measure Strain and Temperature

Selwan K. Ibrahim⁽¹⁾, John A. O'Dowd⁽¹⁾, Raymond McCue⁽¹⁾, Arthur Honniball⁽¹⁾, Martin Farnan⁽¹⁾, Devrez M. Karabacak^(1,2), Jan Van Roosbroeck⁽³⁾, Bram Van Hoe⁽³⁾, Johan Vlekken⁽³⁾, Eric Lindner⁽³⁾, Johannes M. Singer^(1,2)



www.faztechnology.com

⁽¹⁾ FAZ Technology Ltd., 9C Beckett Way, Park West, Dublin 12, Ireland

⁽²⁾ Fugro Technology BV, Veurse Achterweg 10, 2264 SG Leidschendam, The Netherlands

⁽³⁾ FBGS International, Bell Telephonaan 2H, 2440 Geel, Belgium

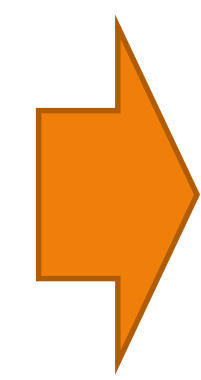
Email: selwan.ibrahim@faztechnology.com



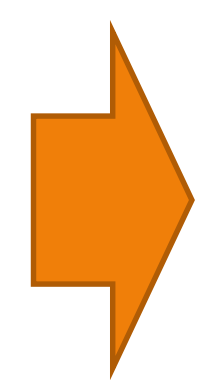
www.fbgs.com

FBG challenges

- Limited mechanical strength due to strip and recoat process
- Cost effectiveness of multiplexing tabletop FBGs
- Standard FBG: cross sensitivity for strain (ϵ) and temperature (T)
- FBGs in birefringent or Polarization Maintaining (PM) fiber: limited sensitivity to simultaneously measure ϵ and T



DTG approach FBGS



PM fiber technology IPHT

FAZT I4 interrogator platform



Interrogator challenges

- Stability limited to pico-meter range
- Reliability and absolute accuracy
- Polarization can impact performance

FAZT I4 interrogator



- No moving parts
- High precision
- Polarization control

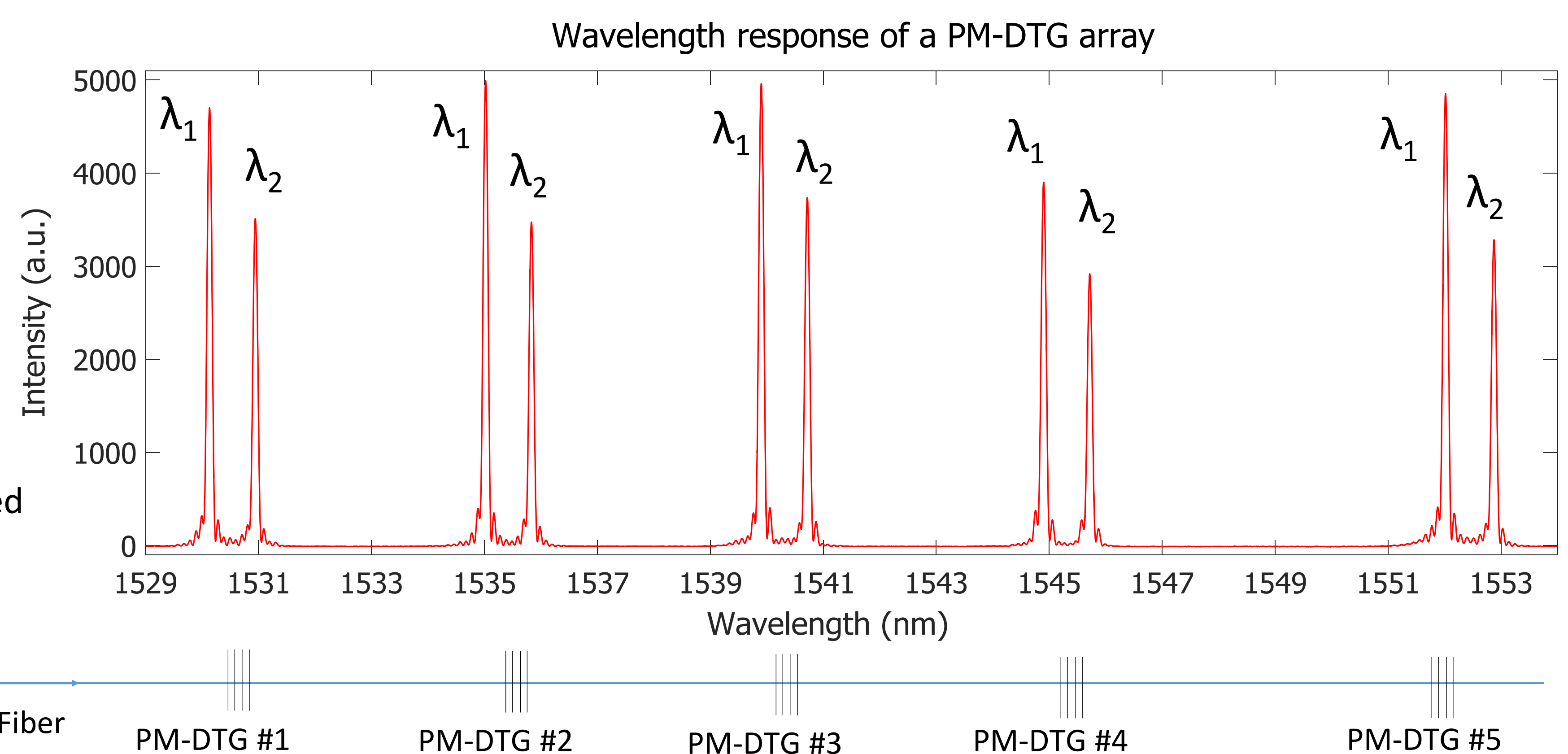
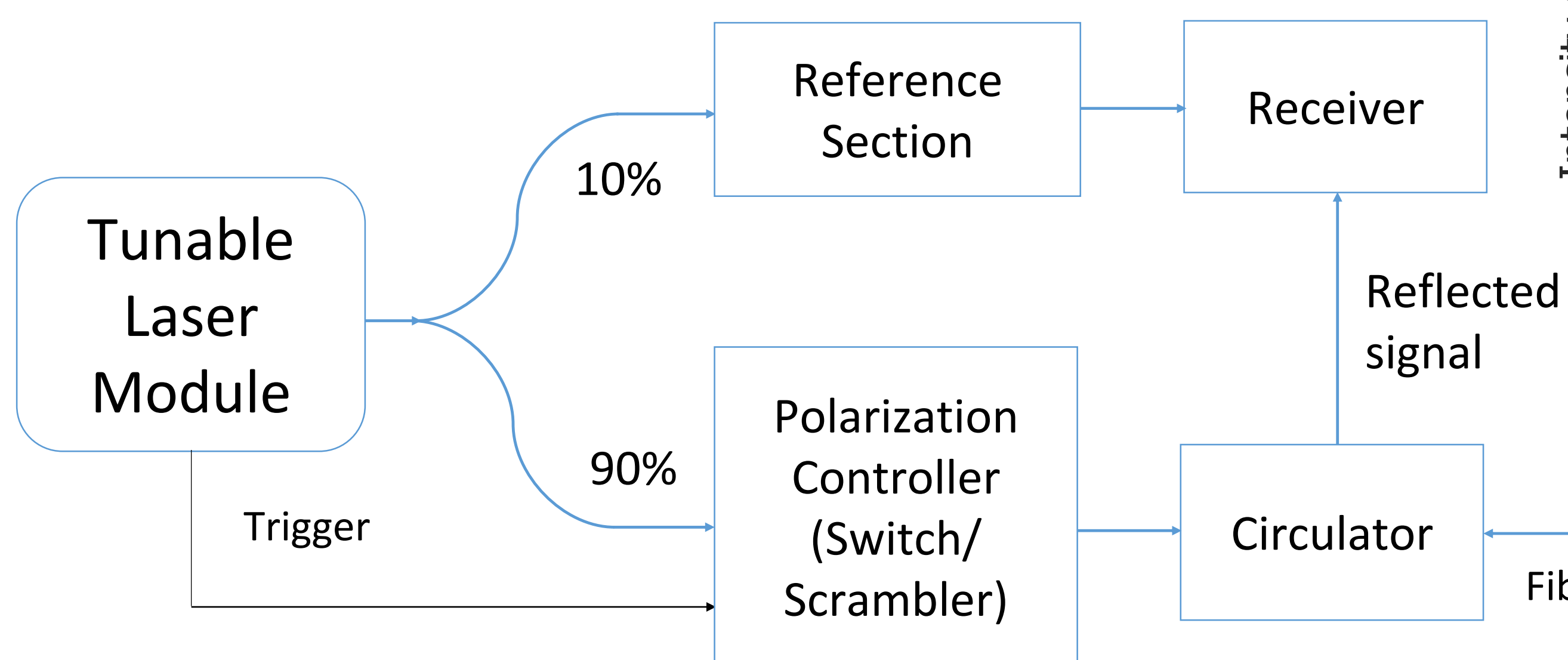
PM-FBG interrogation approach

- Individual λ_1 and λ_2 FBG peaks change with respect to Strain (ϵ) and Temperature (T) similar to standard FBGs
- $\lambda_1 - \lambda_2$ peak separation is mainly governed by temperature dependent birefringence
- A set of linear equations are solved to extract ϵ and T

$$\begin{aligned} \lambda_1 - \lambda_{10} &= a \Delta T + b \Delta \epsilon \\ \lambda_2 - \lambda_{20} &= c \Delta T + d \Delta \epsilon \end{aligned}$$

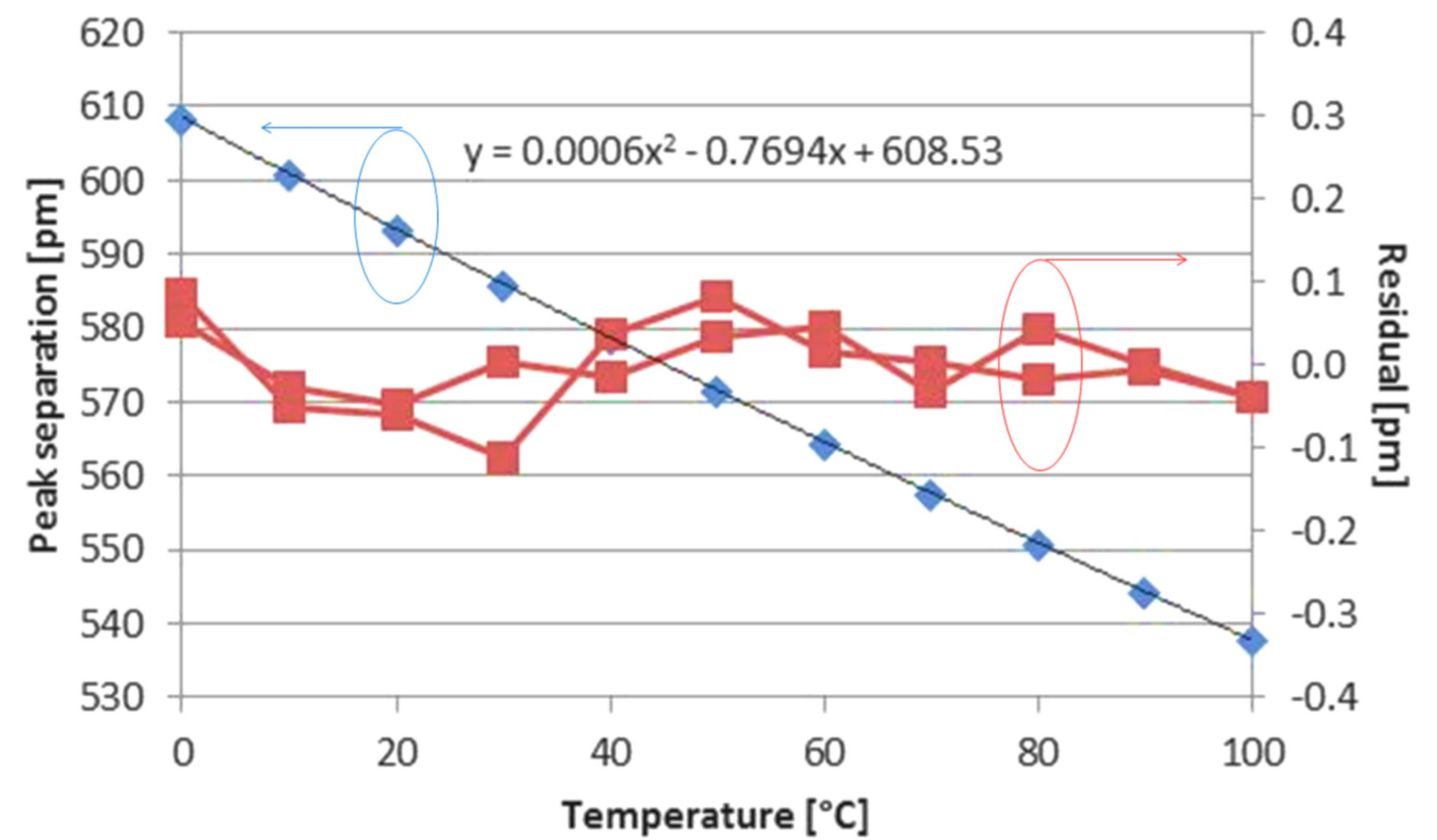
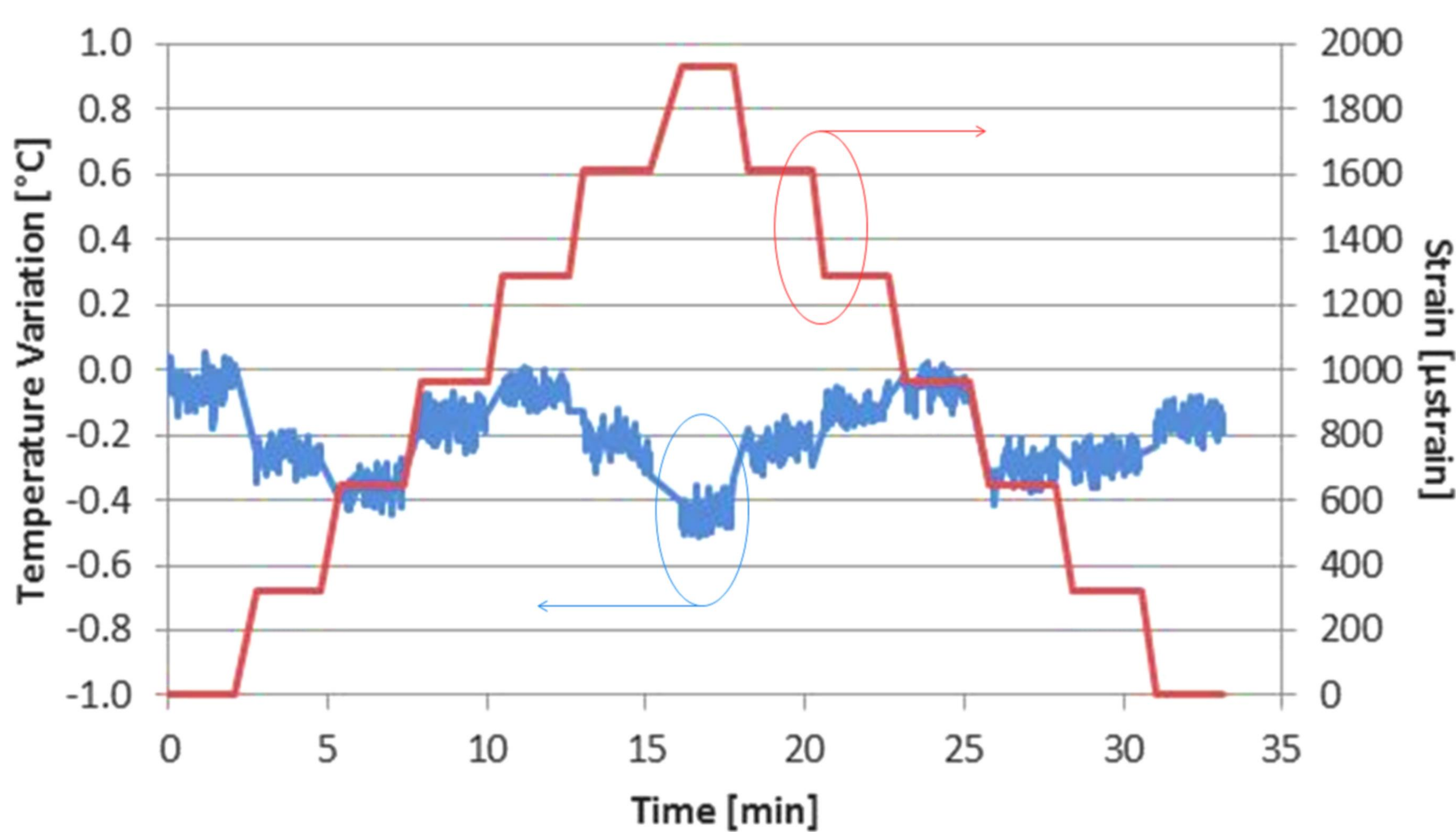


$$\begin{aligned} \Delta T &= (d\Delta\lambda_1 - b\Delta\lambda_2)/D \\ \Delta \epsilon &= (a\Delta\lambda_2 - c\Delta\lambda_1)/D \end{aligned}$$



- PM-FBGs offer enhanced capability of ϵ and T separation
- PM-FBG sensors can be inscribed during the fiber drawing process enabling PM-DTG arrays to be manufactured

Temperature and strain calibration for a single PM-DTG



- Temperature stability during a strain calibration $\sim \pm 0.2^\circ\text{C}$

Conclusion

PM-DTGs from FBGS together with the FAZT I4 interrogator allow for separation of strain and temperature effects with high accuracy, and the interrogation of PM-DTG sensor arrays using different polarization control techniques. Temperature stability of a PM-DTG during a strain calibration was found to be approximately $\pm 0.2^\circ\text{C}$.

This work is supported by ESA under the GSTP6.2 project "Development of a high precision interrogator to acquire data from birefringent FGB sensors, for ground testing of satellites"

