Fiber Optic Distributed Sensing Applications in Defense, Security and Energy.

Mikko Jaaskelainen*
SensorTran, Inc. Austin, Texas, USA.

ABSTRACT

Distributed Fiber Optic Sensing is a powerful technology with wide spread use in applications from down-hole oil & gas wells to environmental monitoring of streams. This paper will highlight some of the various technologies and applications. Recent advances in multi wavelength Raman systems will also be discussed.

Keywords: Distributed Fiber Optic Sensing, Distributed Monitoring Systems, Rayleigh, Brillouin, Raman, Distributed Temperature Sensing, DTS, Hydrogen induced attenuation, steam drive

1. INTRODUCTION

Distributed Monitoring Systems (DMS) are widely used in Defense, Security and Sensing applications and the adoption rate of fiber optic sensing systems is growing across many industries. Attributes like high sensitivity, large bandwidth and wide dynamic range coupled with small form factor, light weight, high temperature performance, immunity to shock/vibration, challenge and displace conventional electrical sensors in many applications. This paper gives a high level technology overview of the most common distributed monitoring systems. A number of applications based on commercially available systems using Rayleigh, Brillouin and Raman scattering are reviewed.

2. BRIEF TECHNOLOGY INTRODUCTION

The majority of Distributed Monitoring Systems are based on Optical Time Domain Reflectometry (OTDR) principle. A very short light pulse is launched into an optical fiber and interacts with the fused silica in the optical fiber. This interaction will cause light to scatter back along the full length of the optical fiber. The backscattered light will consist of 3 different components, Rayleigh, Brillouin and Raman backscattered light, figure 1.

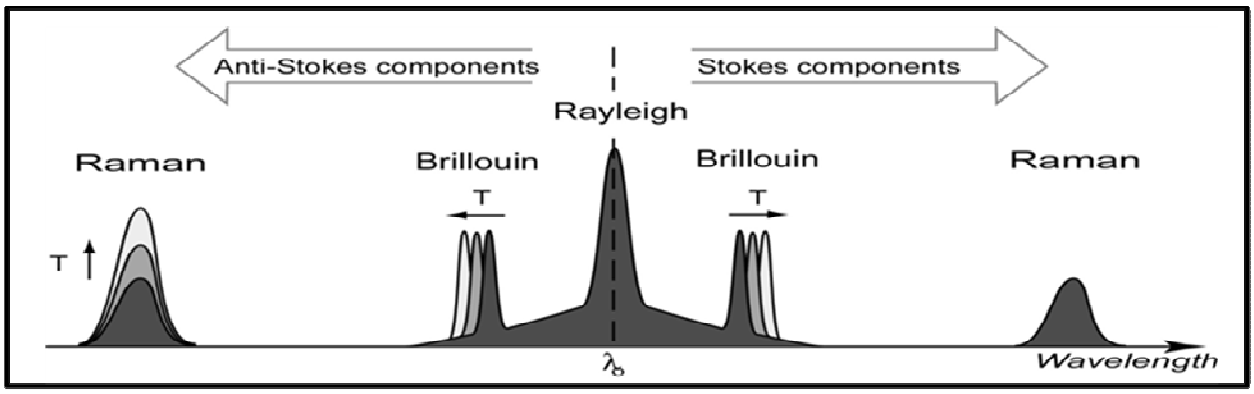

Fig. 1. Backscattered Rayleigh, Brillouin and Raman light in optical fibers.

The Rayleigh component is scattered back at the same wavelength as the launched pulse whereas both the Brillouin and Raman components are shifted in wavelength.

*mikko@sensortran.com; phone +1 281 513 2628; www.sensortran.com

detection systems cannot monitor the rate of temperature rise or the movement of smoke and fire due to the system design.

Environmental applications include distributed temperature measurements in streams, lakes, mines, glaciers, air and snow [21]. For example, to understand the proper habitat for trout and salmon, it is critical to explore the processes that control a stream's peak daily temperature. The endangered Chinook salmon, and many other fish, become stressed and die when rising temperatures simultaneously decrease oxygen content of the water, increase the fishes' base metabolism, and increase the reproduction of parasites, leading to catastrophic die-offs when threshold temperatures are crossed. Better understanding of our environment will allow us to act responsibly and avoid man made disturbances with potential catastrophic effects in our ecosystem.

6. CONCLUSIONS

Distributed Monitoring Systems provide valuable contributions to applications in Defense, Security and Sensing across a large number of applications. The distributed nature of these systems offers unparalleled advantages over electrical systems and new applications develop as the market for distributed fiber optic sensing systems continue to grow.

REFERENCES

[1] Govind P. Agrawal, Non-Linear Fiber Optics, ISBN 0-12-045142-5

[2] A. Dandridge and G.B. Cogdell, "Navy Applications of Fiber Optic Sensors," *IEEE Lightwave Comm. Syst.* 2, 81-89, (1991).

[3] C.K. Kirkendall et al, High-Resolution Fiber Optic Sensing, 2004 NRL Review

[4] C.K. Kirkendall et al, Distributed Fiber Optic Sensing for Homeland Security, 2007 NRL Review

[5] http://www.fft.com.au/documents/SecureFenceCaseStudyUSMilitary.pdf

[6] http://www.fft.com.au/documents/SecureFenceCaseStudyUSRefinery.pdf

[7] http://www.fft.com.au/documents/SecurePipeCaseStudyEuGasCo.pdf

[8] http://www.qinetiq.com/home/security/physical_security/optasense/pipelines.SupportingPar.57981.File.pdf

[9] http://www.qinetiq.com/home/security/physical_security/optasense/pipelines.SupportingPar.64115.File.pdf

[10] Luc Thévenaz et al, Truly distributed strain and temperature sensing using embedded optical fibers, EPFL, Swiss Federal Institute of Technology, Metrology Lab, CH-1015 Lausanne, Switzerland

[11] P.C. Wait et al, Landau Placzek ratio applied to distributed fibre sensing, Optics Communications 122 (1996), P. 141-146.

[12] Marc Nikles et al, Leakage detection using fiber optics distributed temperature monitoring, Proceedings of the 11th SPIE Annual International Symposium on Smart Structures and Materials, March 14-18, 2004, San Diego, Califocnia, USA, pp.18-25.

[13] Benjamin Eisler et al, Distributed Fiber Optic Temperature Sensing System for Buried Subsea Arctic Pipelines, Deep Offshore Technology International Conference & Exhibition, DOT'08, Houston (USA), Feb. 12-14, 2008.

[14] J. Stone, Interactions with Hydrogen and Deuterium with Silica Optical Fibers: A Review, Journal of Lightwave Technology. Vol. LT-5, No. 5. May 1987.

[15] James J. Smolen et al, Distributed Temperature Sensing – A DTS Primer for the Oil & Gas Production, EP 2003-7100, May 2003, Shell International E&P B.V.

[16] Mikko Jaaskelainen et al, Dual Laser Scheme Revolutionizes DTS Deployments, SPE116267, www.spe.org

[17] Downhole Temperature Monitoring, http://www.sensortran.com/downloads.php

[18] Power Transmission Cable Monitoring, http://www.sensortran.com/downloads.php

[19] Intelligent Linear Heat Detection Systems, http://www.sensortran.com/downloads.php

[20] Kent Kalar, Fiber Optics Aim to Improve Leak Monitoring With Distributed Temperature Sensing, Pipeline & Gas Journal, May 2008, www.pgjonline.com

[21] John Selker, Fiber Optics for Environmental Sensing, Sensors Magazine, May 2008, www.sensorsmag.com.