ACOUSTIC EMISSION TECHNOLOGY

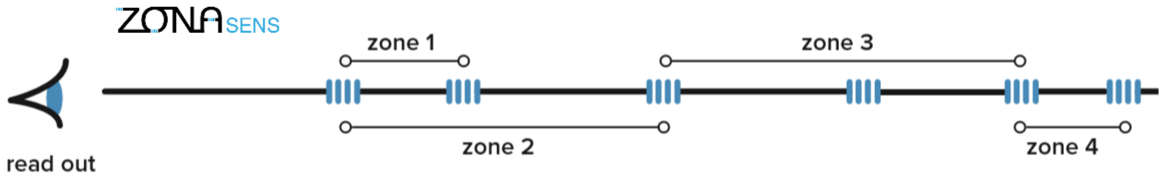
What key problem do we solve?

In high value applications failure prediction and prevention is critical, and therefore (unscheduled) maintenance is extremely costly. Performing accurate measurements on critical components of these systems can enable a prediction of failure, and more importantly, a prediction of when preventive or reparative maintenance is required. This can significantly reduce maintenance cost, up-time and increase safety and performance.

The fiber optical sensors that Optics11 provides perform high accuracy acoustic monitoring in situations where electrical sensors do not match the required performance or boundary conditions. Typical limitations to the application of electrical sensors are:

- Compromised performance in challenging environments (high temperature, remote locations, wetness)
- Sensitivity to electromagnetic interference (EMI)
- Requirement of local availability of power
- Requirement of local bulky electronics to perform pre-amplification and analog-to-digital conversion; impractical and expensive

With Optics11 AE sensors it is not required to choose between speed and sensitivity versus optical advantages, as they excel both in highspeed acoustic emission monitoring and ultimate sensitivity with the advantages of optical sensing. Next to these optical advantages the weight of the AE sensors is significantly less compared to electric sensors, therefore they can be easily placed on structures without having an effect on the structure itself.



The AE sensors are driven by ZonaSens, a technology which is based on optical fiber interferometry: multiple zones or sensors in the optical fiber, with zone lengths of centimeters to meters, can be defined to become extremely sensitive to strain. The beginning and end of a sensing zone are each defined by two Fiber Bragg Gratings (FBGs), small reflective parts inside a fiber. To create an interferometry signal between two gratings, a combination of Michelson interferometers is used. A Michelson interferometer uses just a single reflection on the transducer side that interferes with a reflection in a reference path. Two linearized interferometers form each sensing zone, resulting in a very high sensitivity and a measurement speed of 1 million samples per second. Between the FBGs, the sensitive zone can be wrapped around a mandrill to make an acoustical point sensor.

Alternatively, the fiber can be embedded in a composite material, or directly bonded to a structure. The sensitivity is at the femto-strain level, making direct measurement of acoustic vibrations possible. These benefits will be able to beat competing optical acoustic measurement systems, since the sensitivity is at least 100 better than e.g. Distributed Acoustic Sensing (DAS), which uses brute force calculations and learning algorithms to derive small strains along the fiber, with frequencies up to 10s of kHz but with limited sensitivity on nanostrain level. This sensitivity is required for most acoustic sensing applications.

Competitive advantage

In general, the benefits of optical fibre sensing compared to electric sensing are well known: insensitivity to electrical and magnetic fields, performance in challenging environments such as in liquids or high temperatures, and the ability to cover distances of kilometres without significant signal loss. Many successful technologies are exploiting these benefits by providing for example temperature, pressure or strain measurement systems for challenging industries.

However, the current solutions are typically limited in sensitivity and bandwidth, which keep many applications out of reach for optical fibre sensing. Optics11 steps into this gap, providing solutions for all-optical high-frequency acoustic monitoring. Our technologies offer high sensitivity and high acquisition rates compared to existing solutions and have the possibility to measure many sensors simultaneously with a single read out.

Optics11 acoustic monitoring technology (ZonaSens) uses two Fiber Bragg Gratings (FBGs) in an optical fiber to define a sensitive part of the fiber and using interferometry to very precise measure strain. By principle this results in a high acquisition bandwidth (up to 1 MHz) and high sensitivity (down to femtostrain level).

Two competitive technologies currently dominate the market: standard Fiber Bragg Grating sensing and distributed sensing.

1 Fiber Bragg Gratings (FBGs) are local modifications to the optical fiber that reflect a very sharp wavelength. The wavelength can be tracked with an FBG interrogator, which provides a local point measurement of strain or temperature. The strain can in principle be converted into an acoustic signal, but the sensitivity and noise floor are not good enough to measure most acoustical sources (typically limited to the nanostrain level). These FBG systems are typically used for local pressure, temperature or force measurement.

2 Distributed sensing uses the tiny reflections over the full length of the fiber, caused by imperfections in the material, and uses powerful algorithms to derive a local change in strain. This is very well suited to perform local temperature and pressure measurements at low sensitivity and bandwidth. The most powerful system is Distributed Acoustic Sensing (DAS), which uses brute force calculations and learning algorithms to derive small strains in up to 10,000 points along the fiber, with frequencies up to 10s of kHz but again with limited sensitivity on nanostrain level. The system is very costly and requires up to a month to “learn” its application, before sensible data can be acquired