ECIO 2016
18TH EUROPEAN CONFERENCE ON INTEGRATED OPTICS 2016
18–20 MAY | WARSAW | POLAND

Extreme Fibre Optic Sensing by Utilizing Photonic Integrated Circuits in Dedicated Packages

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The application of superior technology of integrated photonics has proved to be capable of supporting both new and existing sensing and monitoring solutions for challenging environments and demands. Acting in the frontline with the development of extreme performance in fibre sensing already led to the establishment of noteworthy achievements.

The versatile ability to replace traditional assemblies of multiple discrete optical or micro-optical components by a single small sized chip makes Application Specific Photonic Integrated Circuits (ASPICs) increasingly favourable for next generation (fibre) optic systems for benefits in cost reduction, functionality aggregation and standardization of specifications and processes. Improvement of ASPIC buildings blocks with regard to for instance reduced waveguide losses, improved fibre coupling efficiency through spot size converters, modified ASPIC functionality like the AWG (Arrayed Waveguide Grating) for high performance sensing purposes, improved SOA (Semiconductor Optical Amplifier) for fast optical switching, etc., allows the development and manufacturing of versatile and complex optical systems feasible. In addition, ASPIC packaging is playing a significant role in the succession of this technology. Extremely low noise electro-optics is used to connect the ASPIC to the outside world with sufficient SN ratios. Stability is achieved through the implementation of thermal management capability up to μK resolution, using TECs based on FEM models and extensive analysis over local heat sourcing caused by active ASPIC functionality. The first measurement results showed stability within 50 μK over 60 seconds and 400 μK over half an hour. It is believed that this is only the beginning of the thermal controllability of ASPIC based modules.

These qualities and ASPIC behaviour control allows applications where temperature variations and mechanical vibrations of extreme low order can be detected. ASPIC technology has proven to allow $\Delta\lambda$ resolutions of 10^{-15} m and beyond, which can be related to various physical parameters like nε's, μK's, and mbar's – some even discriminated simultaneous. In addition to the sensing resolution, high speed electronic readout is relative easy to accomplish with the integrated photodiodes. For instance, 10 MHz sampling has been achieved for a medical application.

Controlled experiments have demonstrated detection of wavelength shifts down to <0.3 attometer/sqrt(Hz), i.e. 0.2 ppt per sqrt(Hz). The paper and presentation will depict on technical challenges and achievements, development iterations and decisions towards successful implementation of ASPICs into operational high performance products.