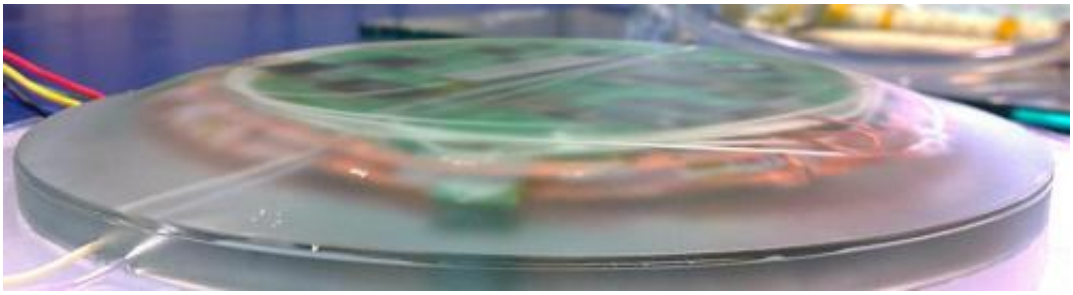
World-first miniaturized fiber-optical monitoring system embedded in composite material

June 30 2014, by Hanne Degans



Interrogator (diameter 10cm) after embedding in protective epoxy shell with shape optimized for minimal impact on composite structural strength.

Nanoelectronics research center imec, Ghent University, and their partners in the European FP7 project SMARTFIBER have demonstrated the world's first miniaturized fiber-optical sensor system than can be fully embedded in a composite material. This achievement paves the way toward smart composites that enable continued and automatic monitoring of the structural health of the composite material in -for example- tidal blades, wind turbines, airplanes (fuselage, wings, …) or marine structures (masts, antennas, hulls of sail yachts, navy ships, propellers).

The sensor system was assembled by Optocap on an electronic board designed by Xenics. The optical subsystem consists of a silicon

photonics integrated circuit developed by imec and photodiodes and read-out ICs provided by Xenics. Fraunhofer IIS was responsible for the wireless interface. It provides power to the embedded system and at the same time reads out the acquired data at high speed. After connecting the system to an optical fiber sensor chain manufactured by FBGS international, it was casted in an epoxy shape specifically designed by Ghent University to minimize the impact on the composite material. Finally, together with the attached fiber sensor chain it was embedded in the blade of a tidal turbine by Airborne.

The silicon photonic integrated circuit, featuring an Arrayed Waveguide Grating (AWG) acting as a spectrometer, forms the core of the sensor system and allows interrogating the Fiber Bragg Grating (FBG) sensors connected to it with high accuracy. The advantages of these FBG sensors compared to other strain monitoring techniques (e.g. electrical strain gauges) are their compactness, light weight, immunity to electromagnetic interferences (EMI), high resistance to corrosion, high temperature operation, and multiplexing capability. The FBG sensors, which exhibit a record small diameter and show unprecedented elongation at breakage, were specifically designed to minimally impact the strength of the composite material. Automatic techniques were developed to embed them in the composite. This, together with the use of silicon-based microfabrication processes on a well-established industrial infrastructure, will enables lowering the cost of embedded strain sensors substantially.

Provided by IMEC