Abstract PhD dissertation Eli Voet:

Aerospace certified fibre reinforced plastics (FRPs) are extreme performing construction materials, which today are increasingly applied in primary structures of the new generation aircrafts (e.g. Boeing 787, Airbus 350, Bombardier C-Series), such as the fuselage, the wings and the fin. An interesting aspect on the technological point of view of sensing is that airplane manufacturers such as Airbus and Boeing are looking at incorporating health-monitoring systems (such as optical fibre sensors, especially fibre Bragg gratings) that will allow the airplane to self-monitor and report maintenance requirements to ground-based computer systems. However, one has to realize that the mechanical behaviour of anisotropic FRPs is significantly different compared to conventional isotropic construction materials.
In this dissertation, the author focuses on monitoring the strain and (permanent) deformation in carbon reinforced plastic laminates with embedded fibre Bragg gratings. The research is divided in two main parts.
In the first part of this research, the existing fibre draw tower technology is utilized, to manufacture an improved version of the existing in-line high quality, draw tower fibre Bragg gratings (DTG®s). With respect to accurate measurements and structural integrity, the research focuses on reducing the total diameter of the optical fibre, so the incorporation in the reinforcement fibres is enhanced and the distortion in the composite is reduced. The author elaborates in detail the methods of strain and temperature calibrations and the different setups which are applied. Additionally, with respect to the high temperatures during the composite manufacturing process, the thermal stability of the DTG®s is studied at elevated temperatures (>300°C).
In the second part, the author embeds the DTG®s in specific types of thermoset and thermoplastic carbon reinforced plastic laminates. The author applies the embedded DTG®s in several stages of the composite lifetime. Starting with the monitoring of the composite manufacturing process and ending with fatigue testing until failure of the composite laminates. During the different experiments, the sensors are subjected to high temperatures, high pressures, extreme longitudinal strains and transverse strains and in the mean time, they are employed to very accurately measure (multi-axial) strains inside composites at microstrain level ($\sim 10^{-6}$).