IOC: INTERNET OF COMPOSITES

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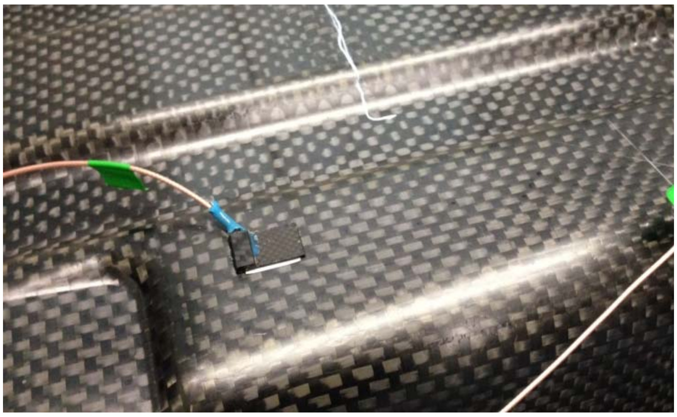
Abstract: *This paper deals with a variety of different sensor types that can be used to monitor composite parts regarding their structural health and its current condition. Monitoring and subsequent management of structural health plays an essential role in composite materials and structures. Structural health monitoring is a new technology which combines intelligent algorithms and sensor technologies to check the "health" condition of structures whenever needed, even in real time. Some benefits of structure health monitoring are the improvement of safety and reliability, the enhancement of performance and operation, reduction of life-cycle costs and the potential for automated unsupervised monitoring. Advancements in structural health monitoring technology have resulted in promising techniques offering autonomous solutions for detecting and assessing the health condition of composite structures, realizing a real-time early warning capability to minimize damage, and reducing downtime and maintenance costs. There is a wide range of systems within the mechanical, civil engineering and aerospace communities where structural health monitoring can be applied to.*

Keywords: *Composites; lightweight; sensor; structural health monitoring*

INTRODUCTION

Composites are made of textile intermediate materials and resins. They offer lightweight potentials of more than 60% compared to steel /1/. Like their aluminum or steel counterparts they are designed to bear high loads and to perform under all circumstances. Sensors can be attached to the parts surface (see Picture 1.) to survey their performance under loading. This approach is called “Structural Health Monitoring” and is a widely used technology to monitor structures and their behavior in aerospace or wind energy.



Picture 1. - Application of a piezo-electric sensor on a surface

Sensors are functionalities usually added to the manufactured parts in an assembly process. Their potential is then harnessed only during the use phase with the customer. Today, due to new sensor systems, fiber reinforced materials and their manufacturing processes, alternative system integration is possible bridging manufacturing and use phase. One of these integrations could be the use of fiber-based sensor systems that are fully integrable in structures (see Picture 2.). This leads to so called “Smart Parts”. The same sensor system provides multiple functions: it can be used during manufacturing (e.g. quality control of production processes) and after that in many different use phase areas, e.g.: E-mobility, Vandalism recognition, HVAC, Chassis monitoring, Structural Health Monitoring etc.

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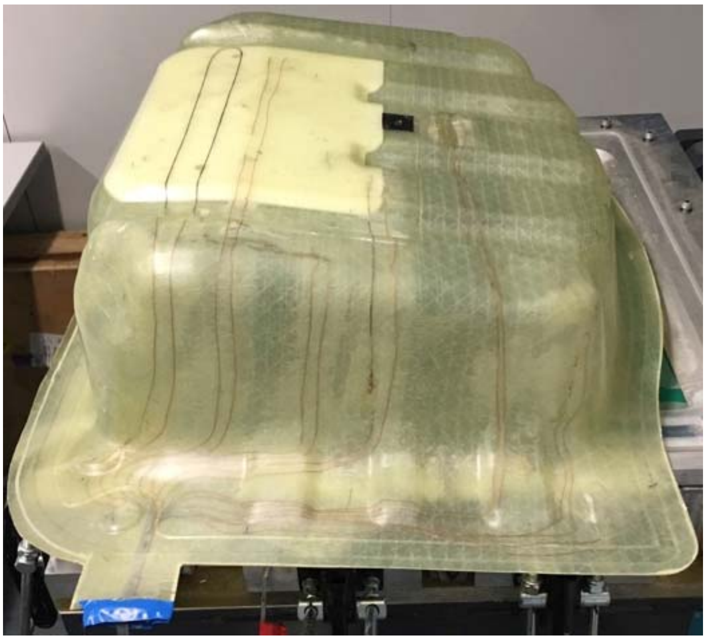
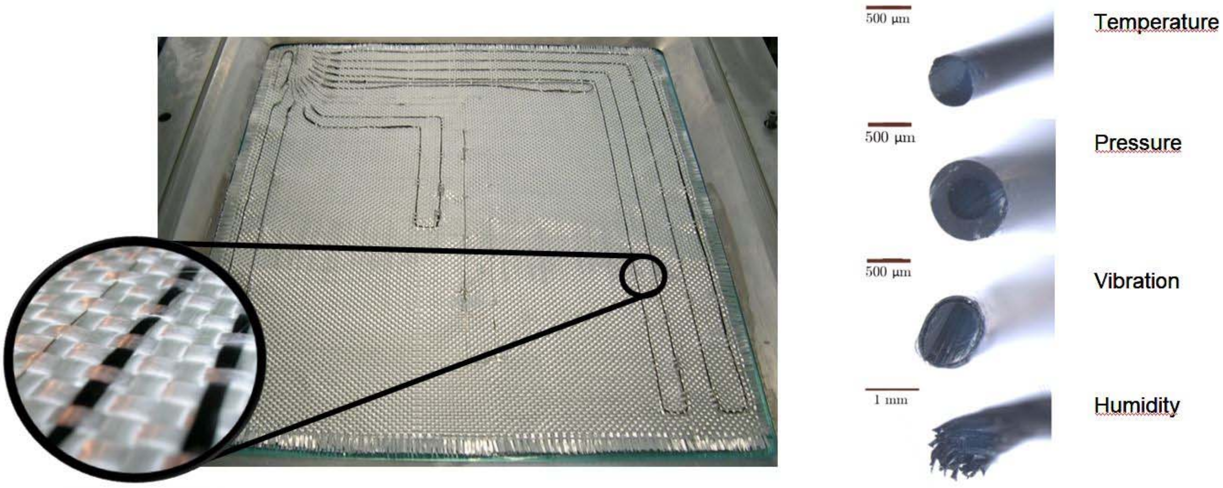


Picture 2. - Embedded Fiber-Sensors into a 3D-Shaped geometry

This paper presents some examples of our developed and under development sensor-systems and its periphery.

Examples

The big advantage of fiber-based sensors (Picture 3.) is their flexibility that enables them to be fully integrated into a textile material. Different sensors can be used to measure temperature, pressure, vibrations or humidity. The humidity sensor can be used for example to monitor the flow front of a resin during infiltration. Later on it can be used to detect a delamination of the composite. A special feature of the vibrations sensor is the possibility to be a sensor and an actuator at the same time.



Picture 3. - Different fiber-based sensors in a textile material

These sensors are a high-performance acoustic emission and dynamic load sensor system. A special feature of this sensor type is its high frequency range. One very interesting application is the detection and localization of impacts onto surfaces and structures. To display and compare this functionality we first joined adhesively four of these sensors from the company iNDTact on an aluminum and a carbon composite plate. After hitting the plate and triangulating the time data of the 4 sensors we can localize the impact area (Picture 4.).

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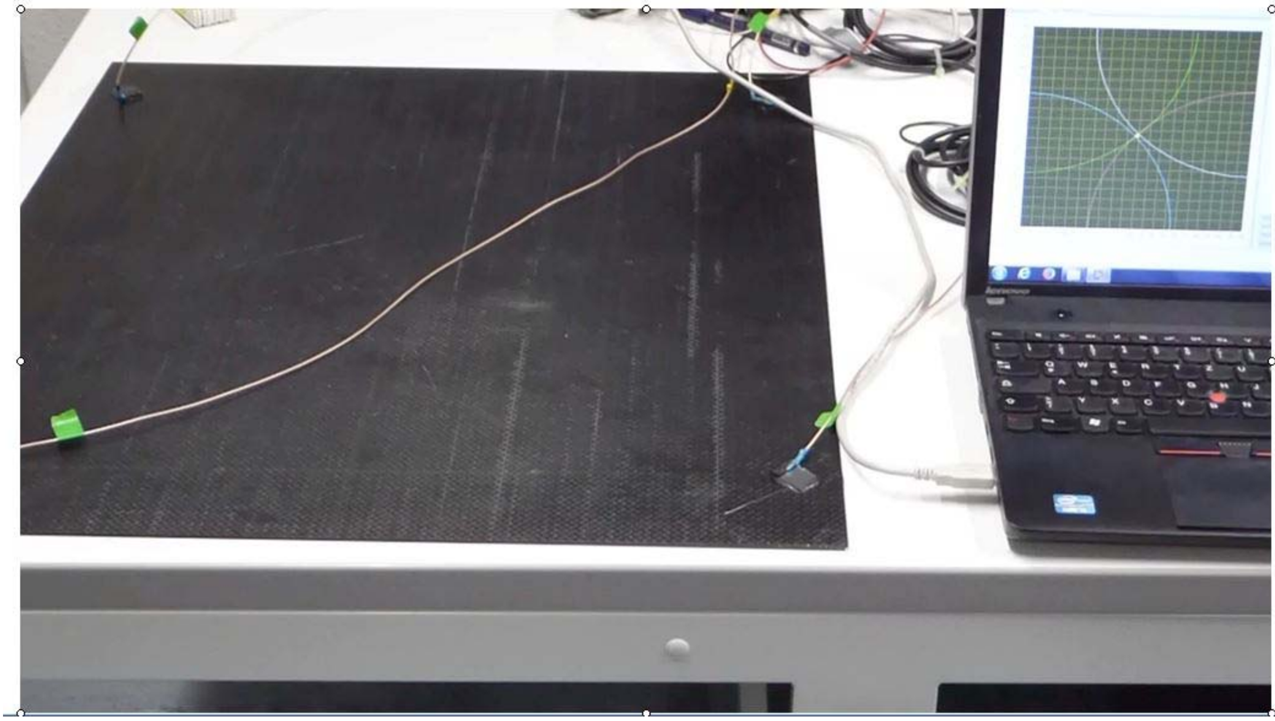

Picture 4. - Carbon composite plate with four acoustic sensors and localization software

The next evolution of this approach is the expansion of the localization software to be able to work for any 3D-shaped Geometry. To demonstrate this we joined adhesively the four sensors on a Mercedes-Benz S-Class AMG carbon spare wheel pan (Picture 3.) and after hitting the pan and triangulating the time data, we can localize the impact area the same way as with the plates. Picture 5. shows the spare wheel pan with the sensor array and a measurement result.

Picture 5. - Mercedes-Benz S-Class AMG Carbon Spare Wheel Pan (left), measurement result representation (right)

The sensibility of the sensors enable them as well to be used to perform a condition monitoring for bearings according to VDI 3832, which can be used for a predictive maintenance application /2/ (Picture 6.).

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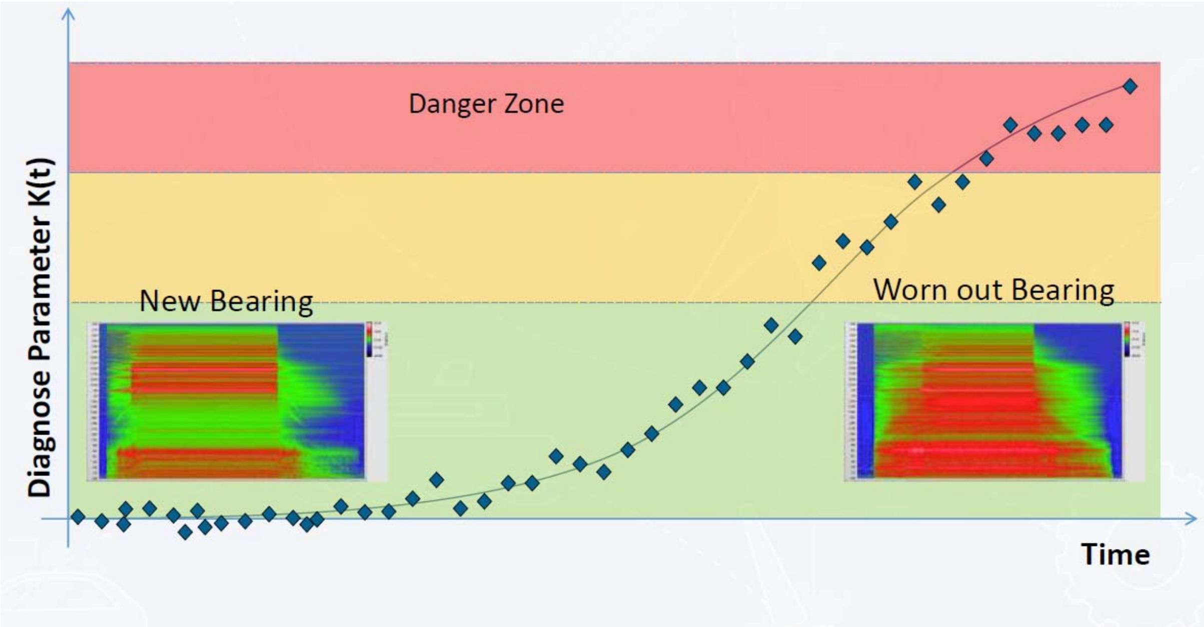
Together with our partner iNDTact we are developing smart composite parts for condition monitoring allowing predictive maintenance.

The goal is to adapt iNDTacts proprietary software solution and to combine it with embedded sensors in composite parts.



Picture 6. - Condition monitoring for bearings according to VDI 3832 /2/

Another aspect of these sensor-systems that needs to be considered is an autonomous power supply. We are currently in contact with a company from Taipei, called ProLogium Technology Co., which produces flexible lithium ceramic batteries that have a thickness of around 0.4 mm and a temperature resistance of up to 120 °C. Due to these properties, we investigate the possibility to implement them together with a data acquisition unit, a wireless data transfer unit (Bluetooth or Wi-Fi) and specific sensors directly into composite parts during the manufacturing process. This offers the opportunity to monitor not only the product during its lifecycle but also during its manufacturing process itself.

Picture 7. - Example of a flexible lithium ceramic battery /3/

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/2/ https://www.indtact.de, 25th April 2018

/3/ http://www.prologium.com, 24th April 2018

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