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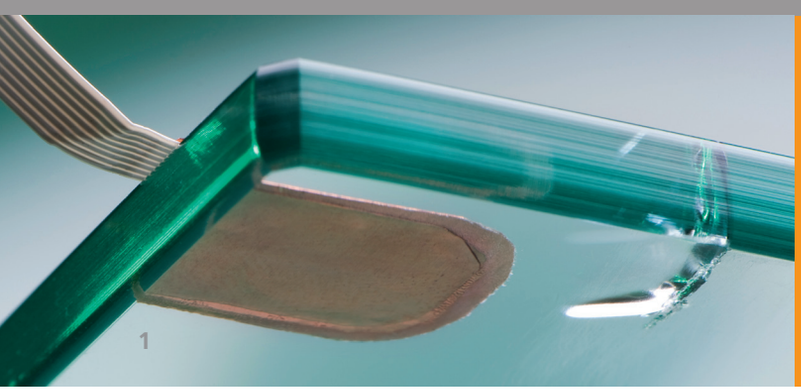

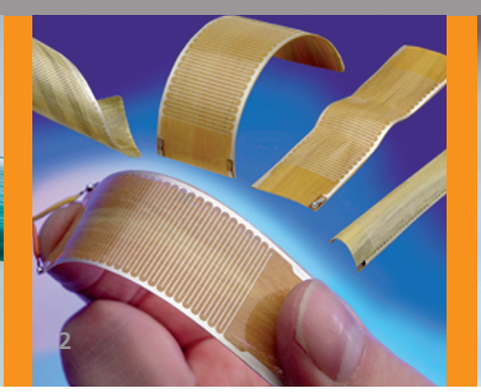

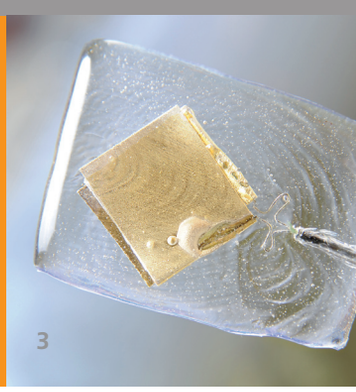

1 *Piezoelectric sensor for the detection of cracks in glass plates*
2 *Piezoelectric fiber composites*
3 *High temperature ultrasonic transducers*

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PIEZOELECTRIC TRANSDUCERS FOR STRUCTURAL HEALTH MONITORING

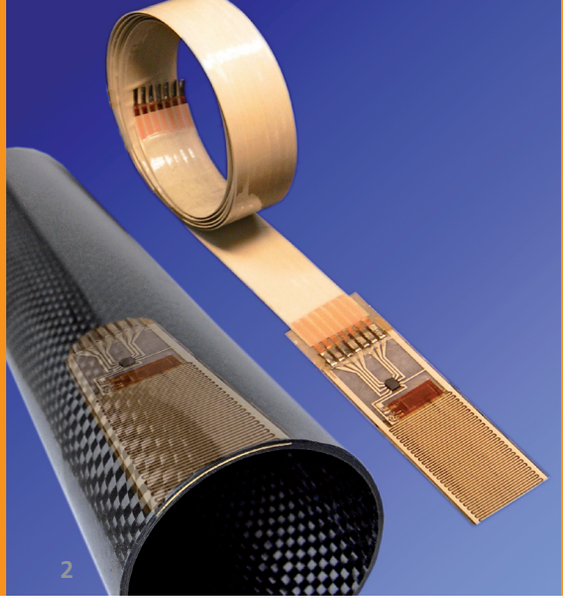
Motivation

The components of a technical system that are relevant to its function and safety are usually checked at regular intervals in order to ensure that the overall system continues to operate smoothly. This type of maintenance work is time-consuming and labor-intensive. It also leads to downtimes that add up to the cost. By employing innovative structural health monitoring (SHM) concepts, it is possible to increase the safety, extend uptimes and reduce maintenance cost, thereby sustainably increasing the cost-effective operation of the technical facilities.

Piezoelectric transducers for SHM of fiber reinforced polymers

Piezoelectric ultrasonic transducers can detect fine structural damage in a variety of materials such as glass fiber composites, carbon fiber composites and steel parts. They are therefore well suited to the structural monitoring of rotor blades in large offshore wind farms. The transducers, which are just 0.5 mm thick and a few centimeters long, can survey large areas of a few square meters, which means that only a few are required to establish an unbroken network of sensors covering the areas of a rotor blade that are at particular risk.

At the heart of the new monitoring solution there are specially modified piezo fiber composites developed by the Fraunhofer ISC. Using the control electronics developed by the Fraunhofer IZFP-D, the piezoelectric fiber bundles in the transducers are stimulated to produce ultrasonic vibrations that spread in waves through the component's surface. Cracks and other damage alter the otherwise steady wave field and are thus easily detected.



The fact that the transducers can alternately function both as receivers and as ultrasonic transmitters makes it possible to generate wavefronts at different points of the part and to check even the most inaccessible corners.

High temperature ultrasonic transducers for SHM of hot pipes

Another promising area of application is the monitoring of hot pipes used to transport chemicals or steam at temperatures of up to 700 °C, a situation frequently encountered in the chemicals industry and in power generation plants.

PZT-based sensors are not suitable for use in high-temperature environments due to their low Curie temperature. High-temperature-resistant ultrasonic transducers specially developed for this purpose are based on single-crystal materials. For passivation, and also for subsequent mounting of the transducers in the chosen locations, the Glass competence team of the Fraunhofer ISC has developed a special glass solder. The connection to the measuring electronics is established using noble metal electrodes.

This solution enables a monitoring of steel pipes at a temperature of up to 700 °C, in which the function of components can be periodically or continuously monitored on site with the aid of sensors. With these kinds of condition-dependent maintenance strategies, components only have to be replaced or repaired if they are genuinely no longer fulfilling their function to an adequate degree or if crack development is detected as evidence of impending failure.

Detection of cracks in glass plates

There is a strong trend in modern architecture towards large glass surfaces. These have to meet very stringent requirements in terms of safety or climate and lighting control. And yet there are no suitable monitoring tools available to provide timely warning about the fracture of a glass element, let alone about possible transport damage it may have suffered even before its installation.

A newly developed sensor module system based on modified low-cost piezo sensors can detect even the smallest cracks, measuring just 5 mm in length. In addition, further sensor functions can be integrated to monitor and control the individual room climate, for example.

The system employs piezoelectric sensor-actuator modules which either generate or receive ultrasonic surface waves with frequencies of up to 200 kHz. The monitoring software correlates the resulting ultrasonic images of the glass elements in question with reference images of the respective elements in undisturbed condition. Deviations can no longer go unnoticed.

1 *High temperature ultrasonic transducer on a steam pipe*
2 *Integrated piezoelectric fiber composite with ASIC preamplifier for vibration and strain measurement*