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Intelligent Bonds for Ship Windows

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Abstract:

This paper and presentation is presenting the scope and motivation for the national German research project. The project is funded by the Maritime Research Program which is an initiative of the Federal Ministry for Economic Affairs and Energy (BMWE).
The project is a cooperation between ABEKING & RASMUSSEN Schiffs- und Yachtwerft SE, Sensorise GmbH, Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Hamburg University of Technology (TUHH), Institute for Ship Structural Design and Analysis, TILSE GmbH and S.M.I.L.E. Engineering. The project started in November 2025 and lasts 3 years.

Glazing plays a central role in the construction of cruise ships and mega yachts. The demand for panes with very long edges (> 10 m) and in challenging installation situations, such as below the waterline or overhanging, is constantly increasing (Figure 1).

Figure 1: Megayacht Excellence (Abeking & Rasmussen)

This involves high and complex stresses on the adhesive bonds, consisting of visible joints and adhesive layers, as well as the joining partners, i.e., the pane and the ship structure. There is little experience with such adhesive bonds and their aging. As a result, such demanding glazing is not implemented or is subject to high restrictions. One solution would be non-destructive testing methods for highly elastic adhesive bonds, which are currently proving to be inaccurate or inapplicable. There is therefore a great need for sensor technology that can continuously assess the condition of the adhesive bond.

Numerical simulations and experiments that analyze the stresses on the adhesive bonds are used to identify areas subject to high stress. Findings about suitable sensor requirements and positions are thus derived.

The experiments will involve large scale experiments at TUHH (Figure 2), where a representative window structure with at least two windows will be subjected to representative loads while monitoring the readings of the sensors. The experiments will include the additional external measurements for the verification of the bond embedded sensors.

Figure 2: Large test lab with dimensions suitable for a realistic window structure (TUHH)

Various sensor concepts are developed, tested, and checked for possible weakening of the joint. The most promising sensor concepts are tested in detail in test specimens and demonstrators. To this end, defects are introduced into adhesive bonds and the sensor signals obtained are evaluated in terms of their informative value.

A sensor that provides data on the condition of the bond continuously or at maintenance intervals increases safety and confidence in the adhesive bond, enabling innovative designs with adhesive bonds that could not previously be realized. In addition, sensor data enables feedback for the purpose of optimal design and adhesive selection in future ships. Unnecessary repairs could also be avoided in this way.