Feature, transduction analysis of the devices and methodological studies for preventive conservation

Prof. Carlo Trigona

Pillar Cultural Heritage – Spoke 1 WP 6 - Task 2

SAMOTHRACE 2nd Year:
Experimental Prototypes Demo Showcase

SAMOTHRACE PROJECT ECS00000022

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Ministero dell'Università e della Ricerca

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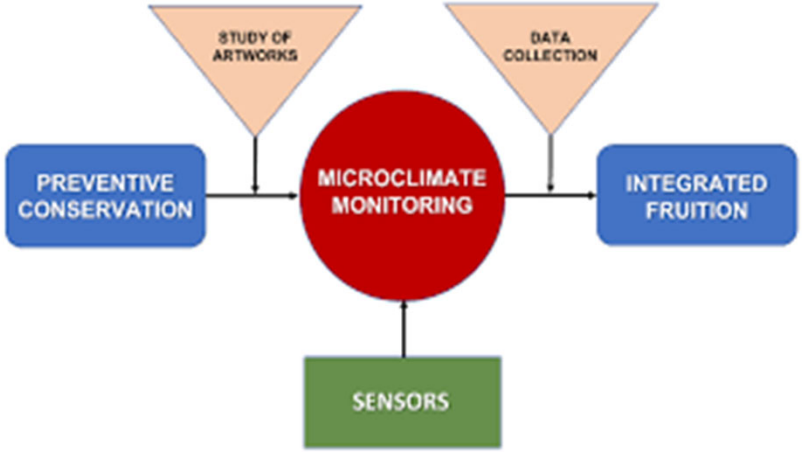
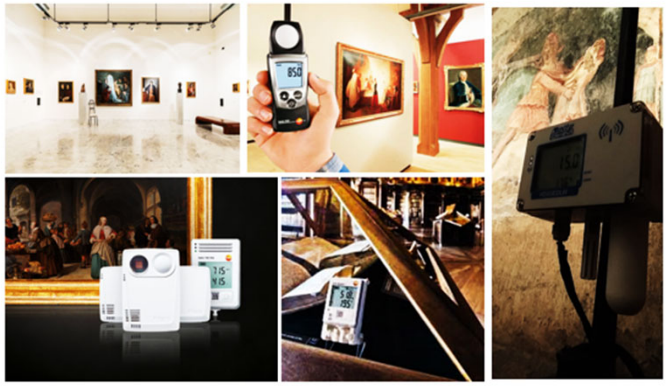
AlN-MEMS for preventive conservation

- Museums require environmental monitoring to protect collections without disrupting the atmosphere of the space. Existing solutions often fail to deliver accurate measurements and can create "**visual pollution**" due to bulky, disruptive sensors.
- In this context, the target audience includes museums, galleries, conservators, and cultural heritage institutions.
- Existing systems are intrusive, require maintenance, and are not low-power, leading to frequent battery replacements.
- It is important to note that the global museum market is valued at **$50 billion**, with a growing demand for effective preservation solutions.



"classic "Measurements systems



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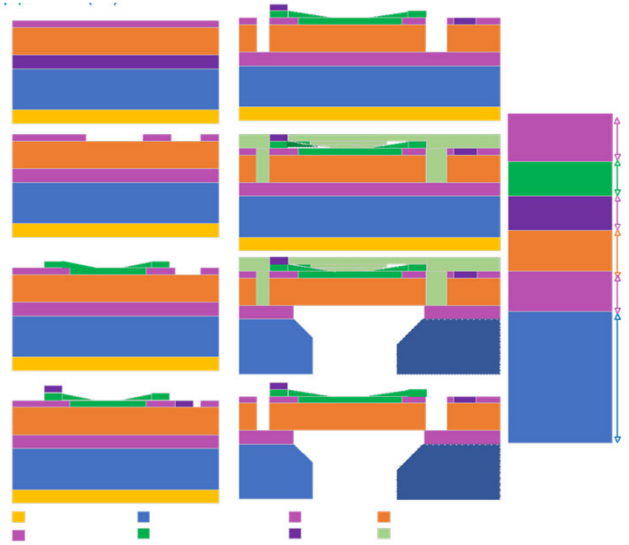
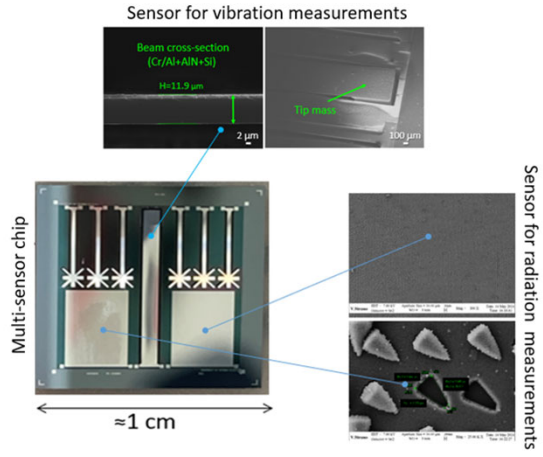
AlN-MEMS for preventive conservation

- The AlN-based MEMS can implement sensors for microclimate monitoring. In this demo, the photodiode enables precise **illuminance** which is crucial for cultural heritage preservation.

- Compared to silicon-based alternatives, it offers a wider bandgap, better thermal conductivity, and integrates multiple sensors on a single chip. Notably, AlN is used to reduce the device's power consumption.

- Experimental results confirm a clear voltage variation with illuminance, aligning with MATLAB® simulations and validating its effectiveness. Notably, the ability to measure vibrations and temperature was previously demonstrated through **other micromachined devices** integrated into the same chip.





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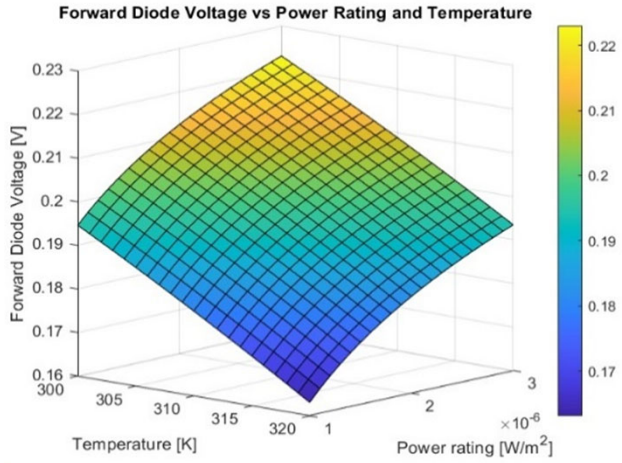
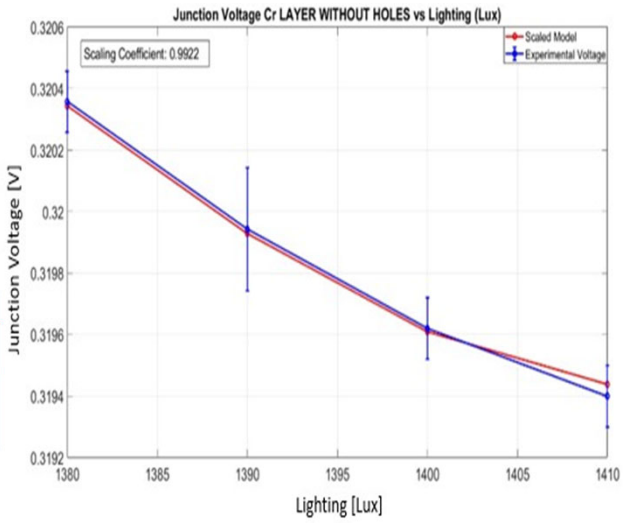
AlN-MEMS for preventive conservation

- The technology was initially at **TRL 3** (experimental proof of concept), with fundamental research demonstrating the feasibility of AlN-based photodetectors and multi-sensing capabilities in lab conditions.With Samothrace funding, the project has progressed to **TRL 5** (validated in a relevant environment).

- Forward voltage as a function of the radiation level and the temperature effect.

- Fitting of experimental voltage (blue) at the junction as a function of lighting and model (red).





$$V_d = \frac{n_{ideal} kT}{q} \ln\left(\frac{I_{PH}}{I_0}\right)$$

Ideality factor · Boltzmann constant · Photocurrent · Junction voltage · Electron charge · Absolute temperature · Junction voltage

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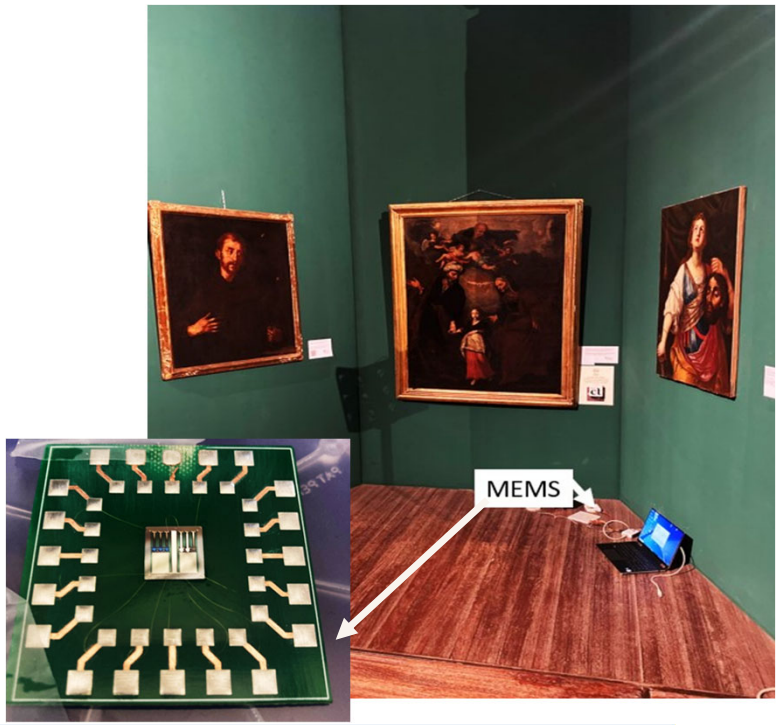
AlN-MEMS for preventive conservation

*Planned Advancements to Achieve **TRL 7** - "System prototype demonstration in operational environment"*:

- Prototype Optimization: Enhance the design and performance of the AlN-based MEMS device for improved sensitivity and features.
- Extended Testing in Relevant Environments: Conduct long-term validation in real-world heritage sites to assess durability and reliability.
- Energy Efficiency Enhancement: Optimize power consumption for prolonged autonomous operation.
- Ongoing cascade funding to address specific areas of interest…

Current validation at the Castello Ursino Museum



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