

BILASURF

D5.3 Online Training Material

Acoustic Monitoring Training

AIMEN Technology Centre



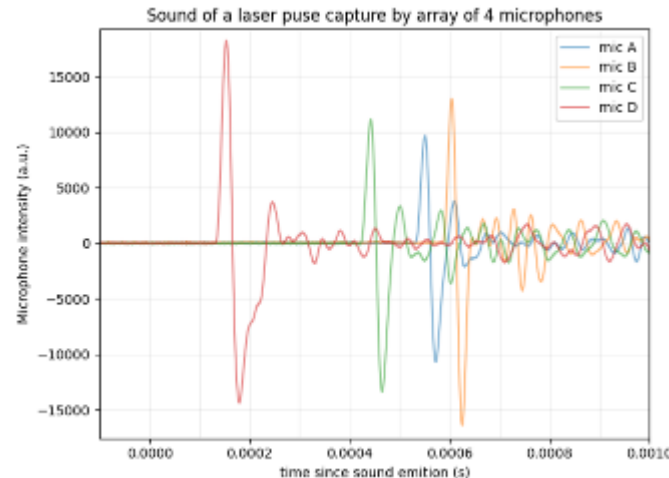
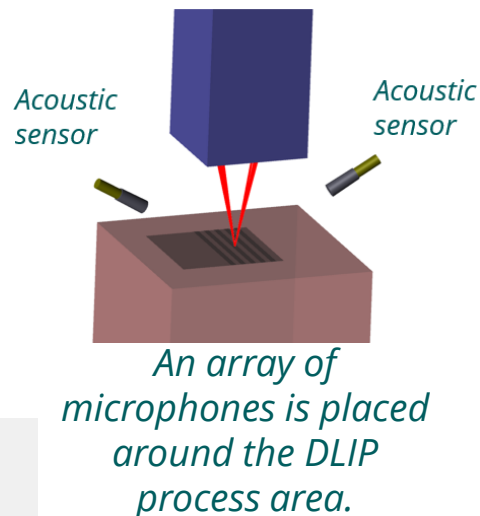
Acoustic triangulation of laser process

An array of microphone is used to identify the position in space of the sound emitted by laser process.

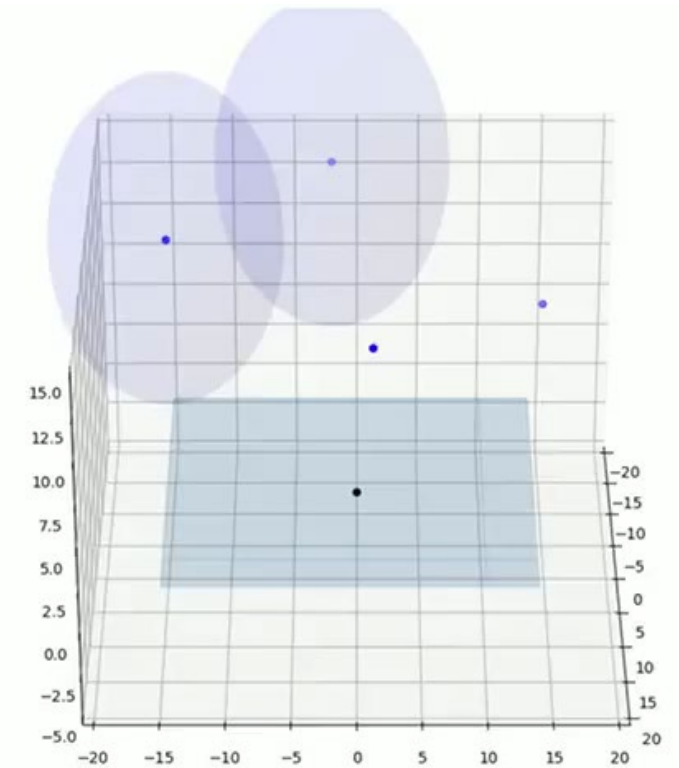
Each microphone will receive the sound at different time. By calculating the difference in time-of-flight we can locate the sound origine.

On pulse-to-pulse data (laser frequency $\sim 100\text{Hz}$), each laser pulse can be identified easily.

On burst mode (laser frequency $>1\text{kHz}$, with ms between each laser pass), typical feature can be identified (beginning of burst for example).



The sound of a single laser pulse arrives at different time on each microphone.



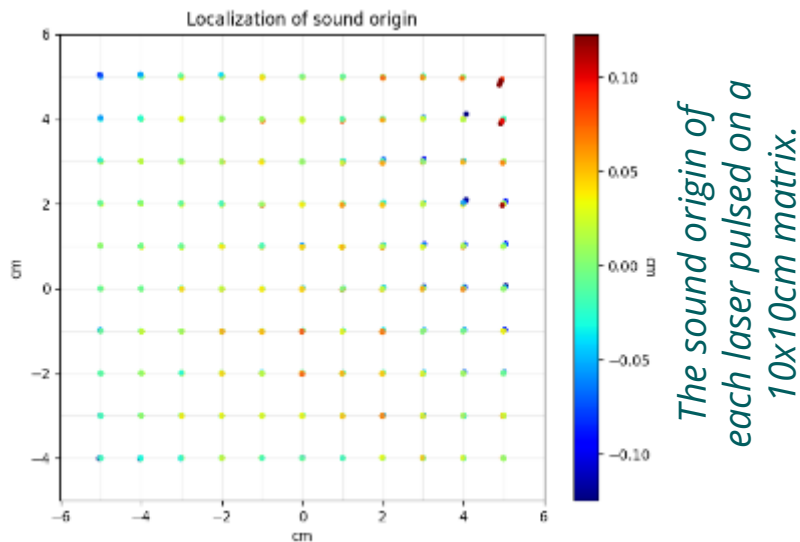
*Trilateration by sphere intersection:
A sphere is drawn around each microphone position based on $\Delta t/v_{\text{sound}}$.
Each sphere radius is increased until first 3 sphere intersect, and then 4 sphere intersect.
The final t is then deduced along with the coordinate of the sound source.*



Acoustic triangulation of laser process

A calibration map can be done, with known location of laser pulse.

The map is $10 \times 10 \text{ cm}^2$ with step of 1 cm.



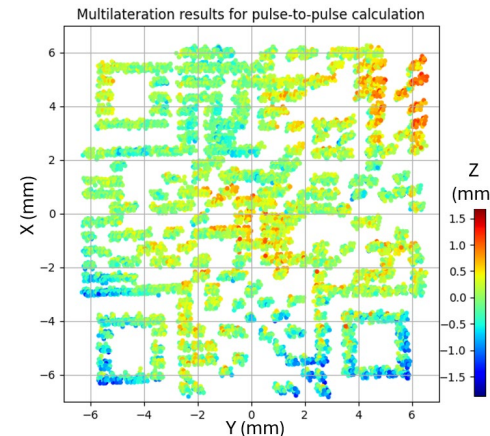
Our method can successfully locate the sound origin along said map.

This technic can be used during process.

Here, a QR code is printed on a sample with a 20 kHz laser. Each square or the QR code correspond to 21 vertical lines.

Each line's sound is analyzed, and the calculated position compared with the reality.

The sound origin of each line marked by the laser.

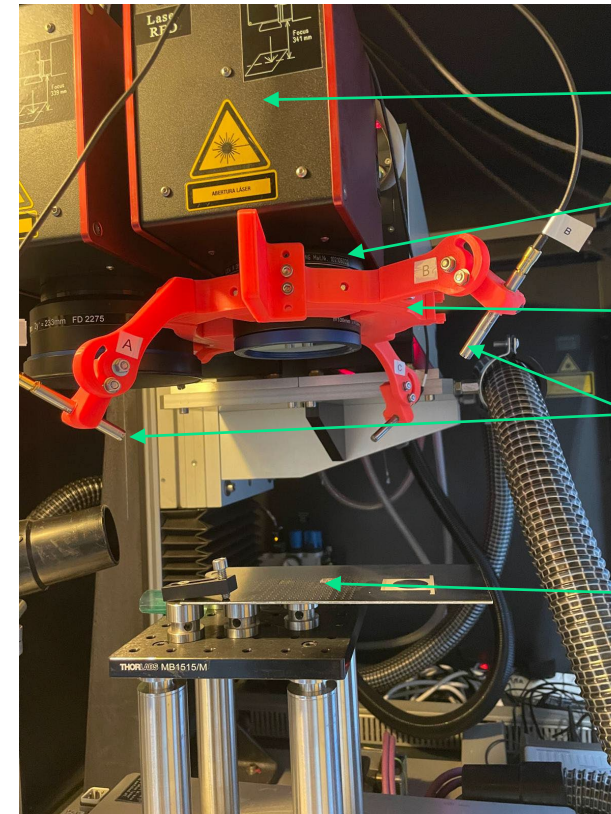
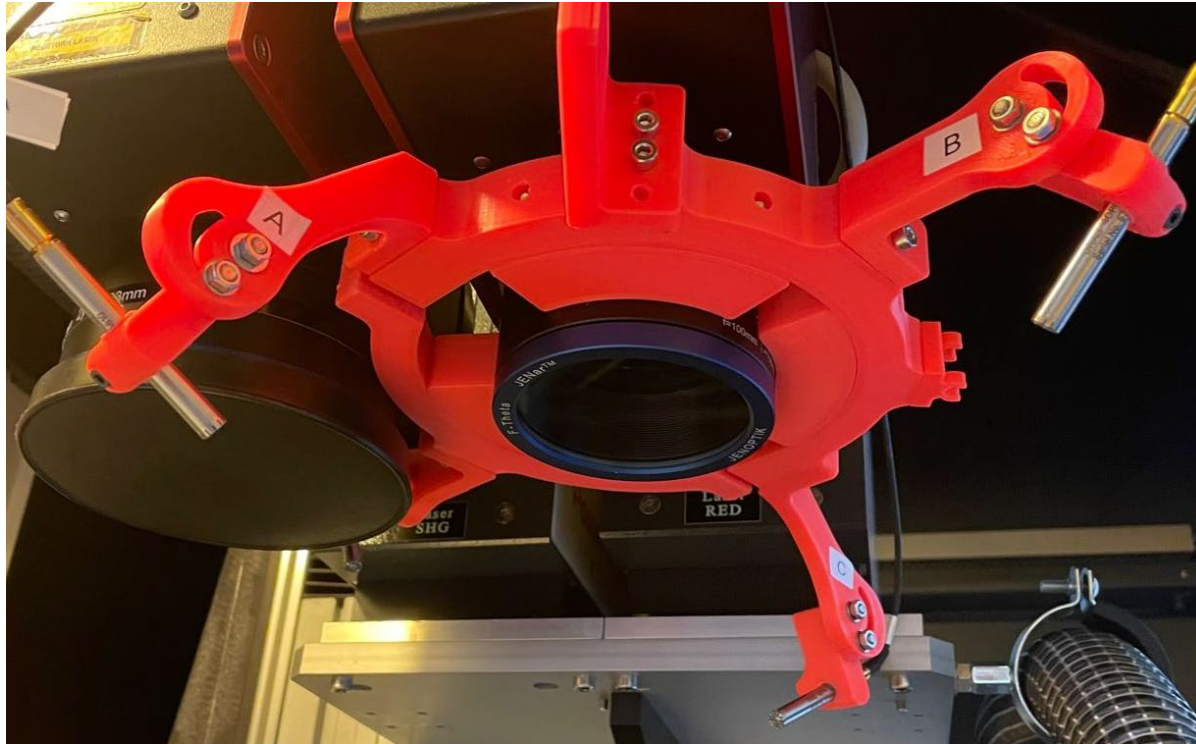


We demonstrated that we can successfully monitor the marking of the QR code with acoustic triangulation.

Integration on scanning laser system

A mounting bracket was designed to fix the microphones on the laser scanning system.

The initial prototype has been made with 3D printing material and fitted onto a laser scanning system at AIMEN. It allows the microphones to be united with the optical setup.



Laser scanning system

f-theta lens

Mounting bracket

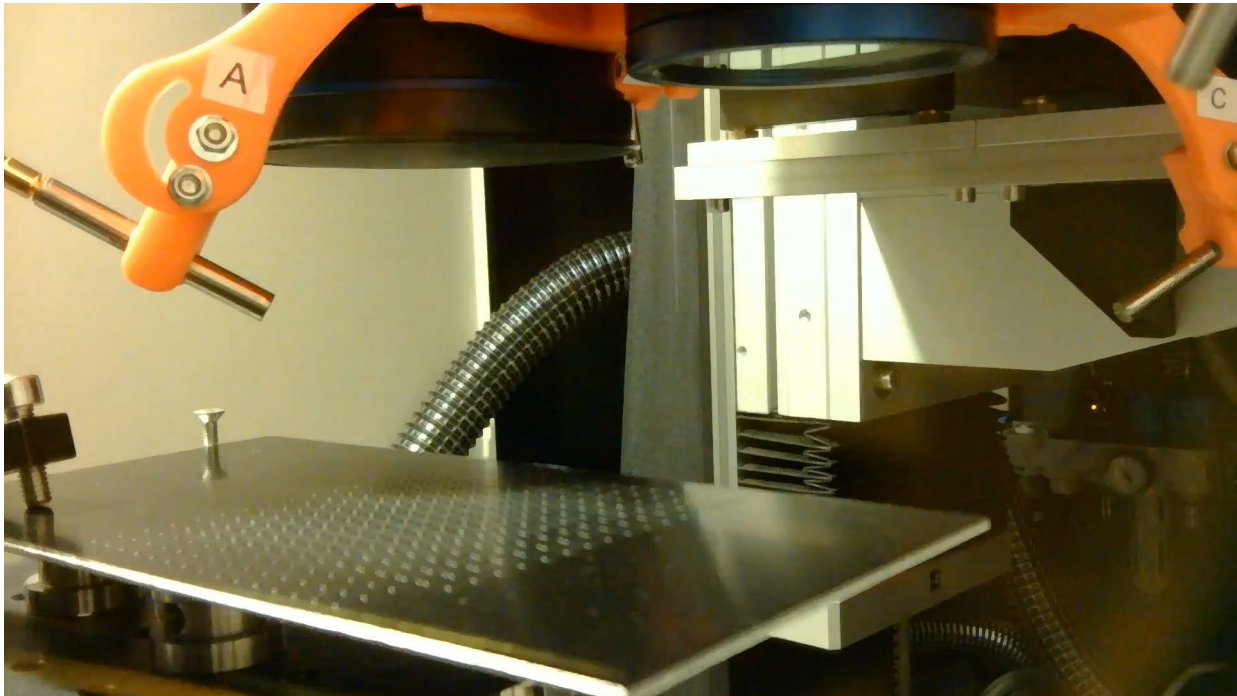
Microphones

Sample to be laser-textured

Control GUI

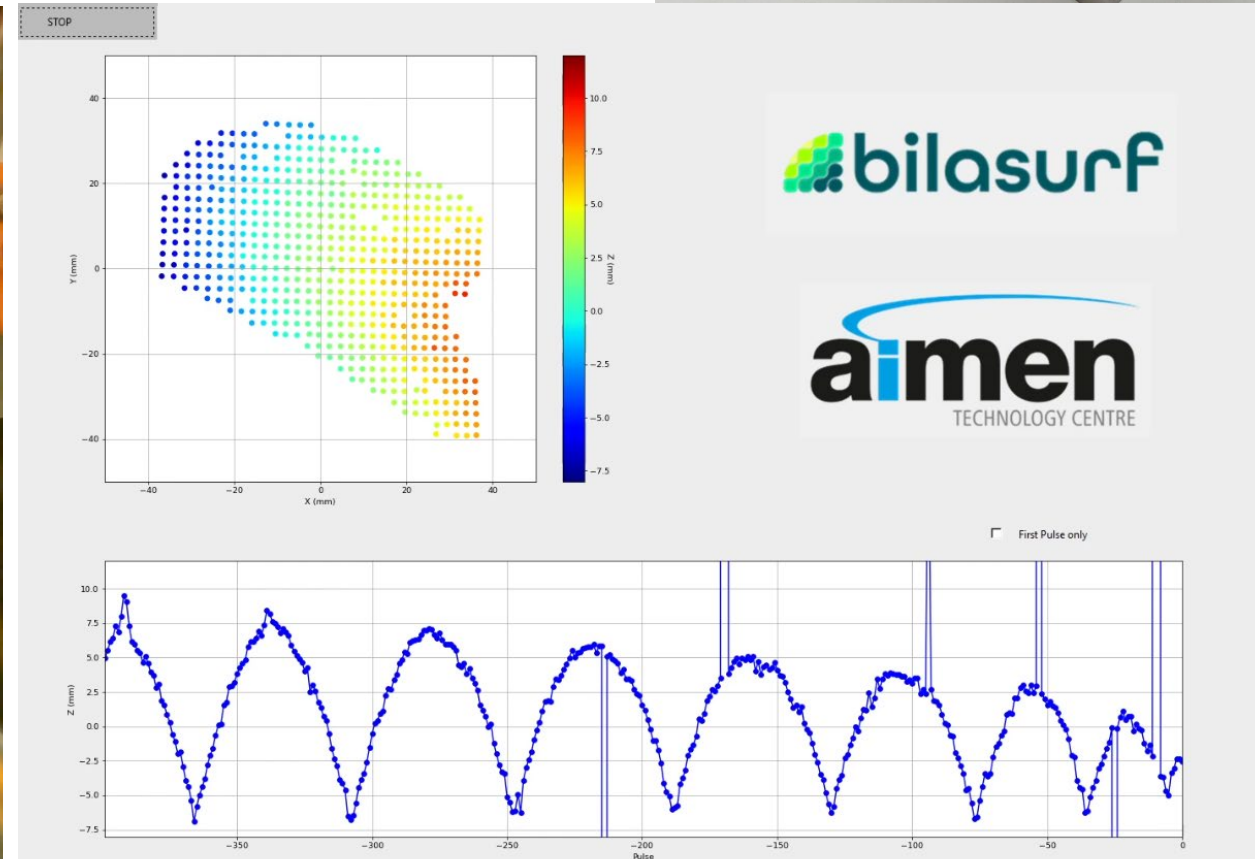
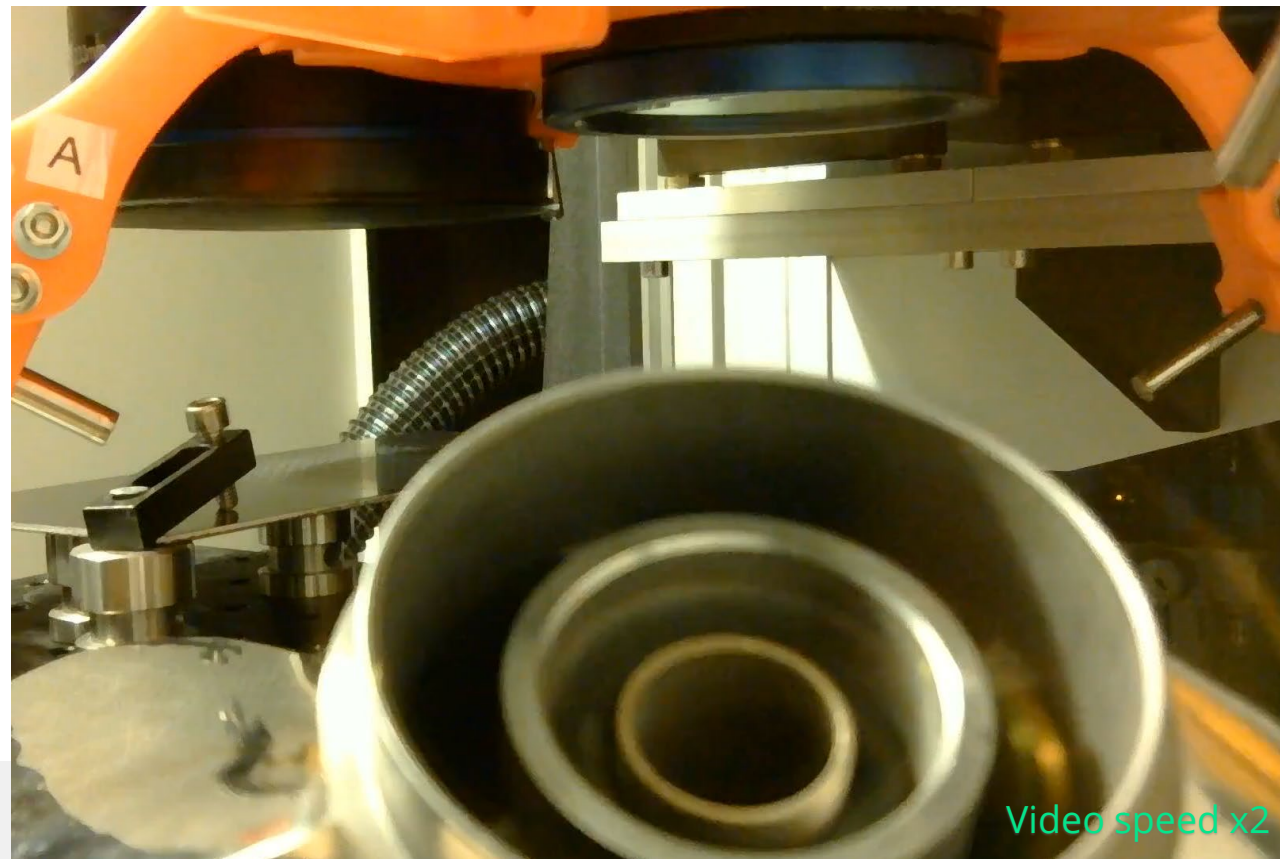
To control the Data Acquisition Device (and therefore the microphones) and allow for a good visualization of the monitoring system, a GUI was developed.

It allows the real-time monitoring of the laser process.



Application: 3D profile of boat propellor

The setup was used while marking a boat propellor, with a 3D curvature.



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Vision monitoring training

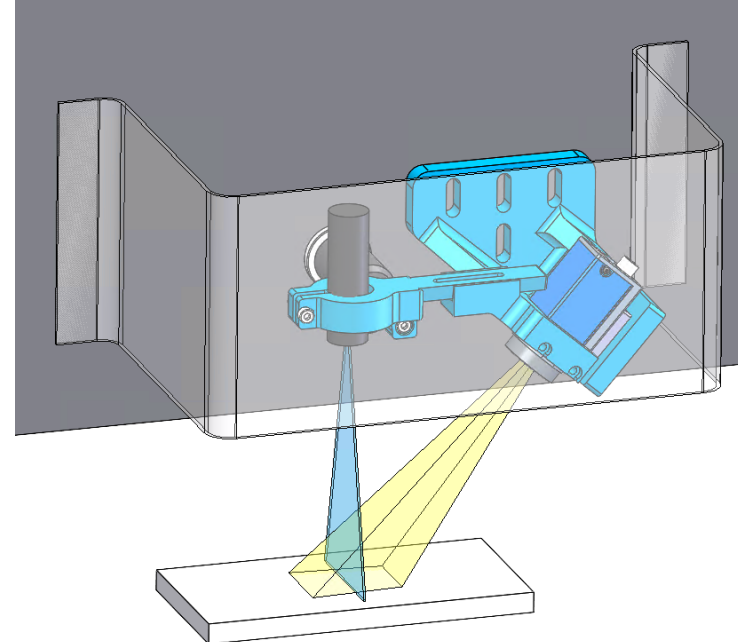
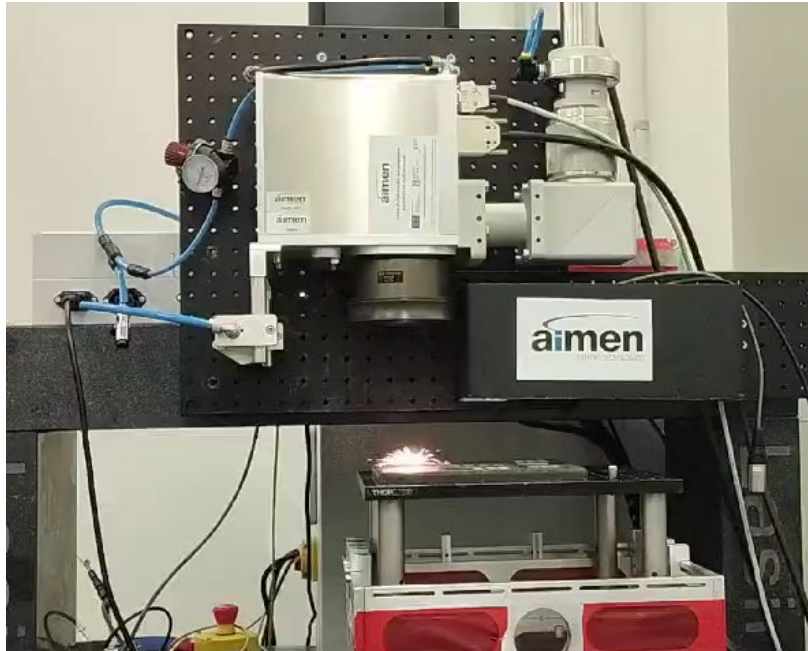
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Vision-based sensor

Additionally, to the acoustic monitoring system, a vision-based sensor was developed, to analyze the riblets-cladded sample produced during BILASURF.

The device was assembled and mounted directly on the processing head, to measure the riblets in-line.

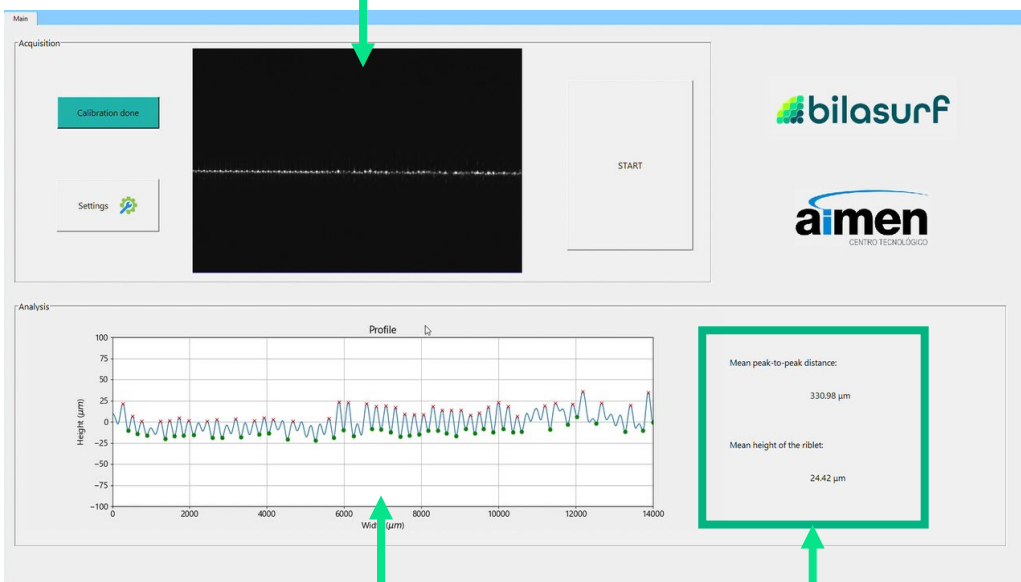




Vision-based software

A dedicated software was made, to calculate and visualize the riblet dimensions (width and height).

Camera view



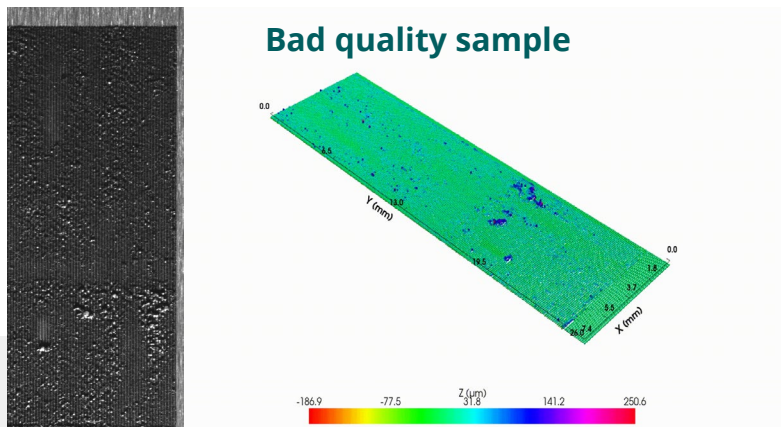
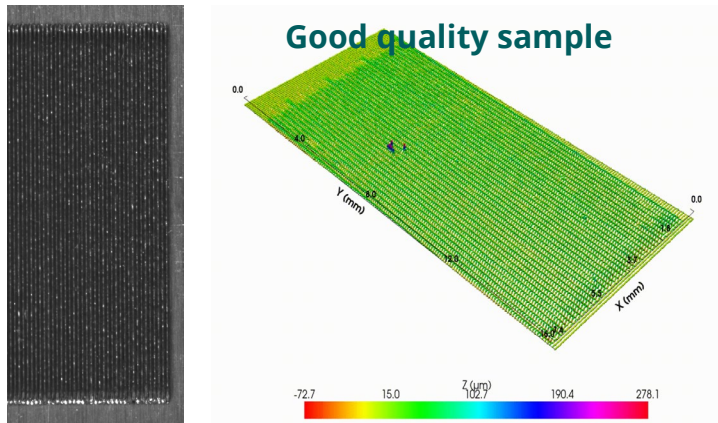
Live profile reconstruction

Live results:
riblet width & height



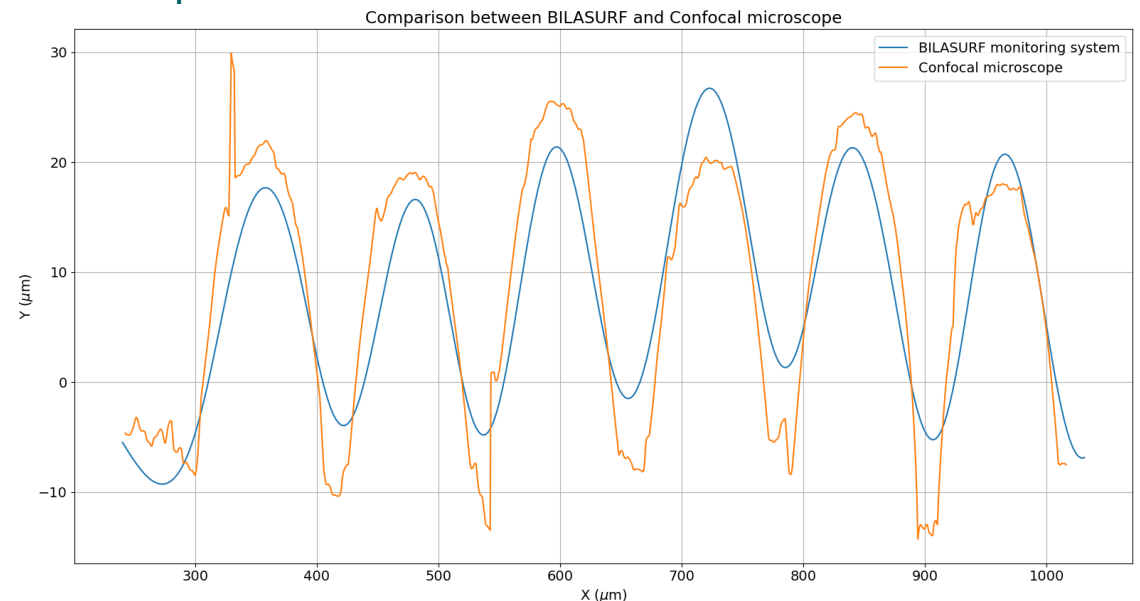
Results

The setup allows for a full 3D reconstruction of the sample and can give KPIs to validate the micro-cladding process.



The results can be compared with confocal microscopy images.

Although the vertical resolution is $6.0\text{ }\mu\text{m}$ (compared to $1.0\text{ }\mu\text{m}$ for confocal microscopy), its high scanning speed makes it a good alternative for in-line inspection.





Thank you for your attention



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