NEWSLETTER 4

HORIZON-CL4-2023-TWIN-TRANSITION-01-02.

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Process Monitoring

This phase of the project aims to advance the state-of-the-art (SOTA) in laser process monitoring by expanding the range of processes addressed within the FLASH project. The SOTA will be pushed further by introducing an automated control step that evaluates whether the process is running correctly and determines if any corrective actions are needed. This improvement is enabled through sensor fusion of optical and acoustic signals.

Acoustic monitoring in laser processing is currently widespread, but it remains unreliable due to the complexity of the acoustic emissions generated during laser-material interaction. Signal quality is also highly dependent on sensor placement. Optical monitoring, by contrast, is well-established for conventional laser processes such as welding and surface texturing. For waterjet-guided laser (WJGL) processing, Synova has developed a patented monitoring system capable of automatic breakthrough detection based on plasma intensity. Recent advances in machine learning now enable more precise and faster monitoring through sensor fusion, paving the way for real-time process control.

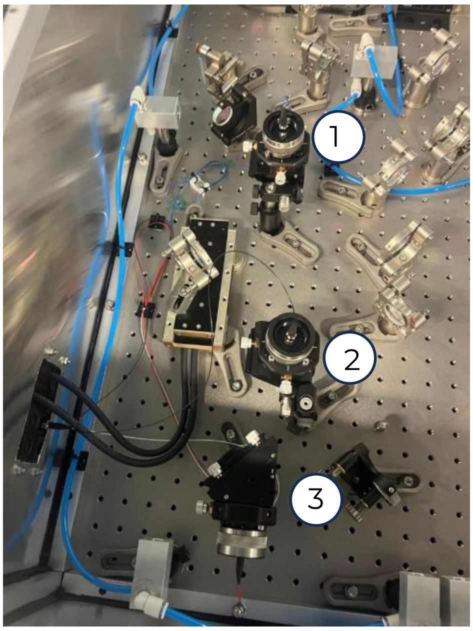

Figure 1: Collimators behind alignment mirrors for optical signal collection (left); Acoustic microphones arranged around WJGL optical head (right)

Through collaborative work between AIMEN and Synova, the optical and acoustic sensors have been successfully installed on the processing heads and within the optical box. Four acoustic sensors are positioned around each optical head to triangulate potential defect locations. They are calibrated up to 100 kHz and can record signals up to 500 kHz. For optical monitoring, three collimators are integrated behind the alignment mirrors of each optical path. The captured optical signals are then split: one part is sent to a broadband (200–1100 nm) spectrometer, and the other to an array of four photodiodes, each targeting a specific wavelength region (UV, 532 nm, 1064 nm, and IR). All signals are transmitted through a DAQ system and processed using a GUI developed by AIMEN for the FLASH project.

Initial testing has begun to assess signal quality, with measurements currently limited to laboratory trials at AIMEN and Synova. An example of acoustic data is shown in Figure 2a, where a deviation from the calibration signal appears at 0.45 s at approximately 40 kHz. This deviation can be traced to a specific location on the sample, which was later verified. Acoustic monitoring has also clearly demonstrated breakthrough detection during WJGL processing (Figure 2c). While it has also been demonstrated that it is possible to retrieve optical signals in a lab based set-up (Figure 2b).

The next steps involve performing in-depth measurements on the FLASH machine and further developing the sensor fusion methodology.

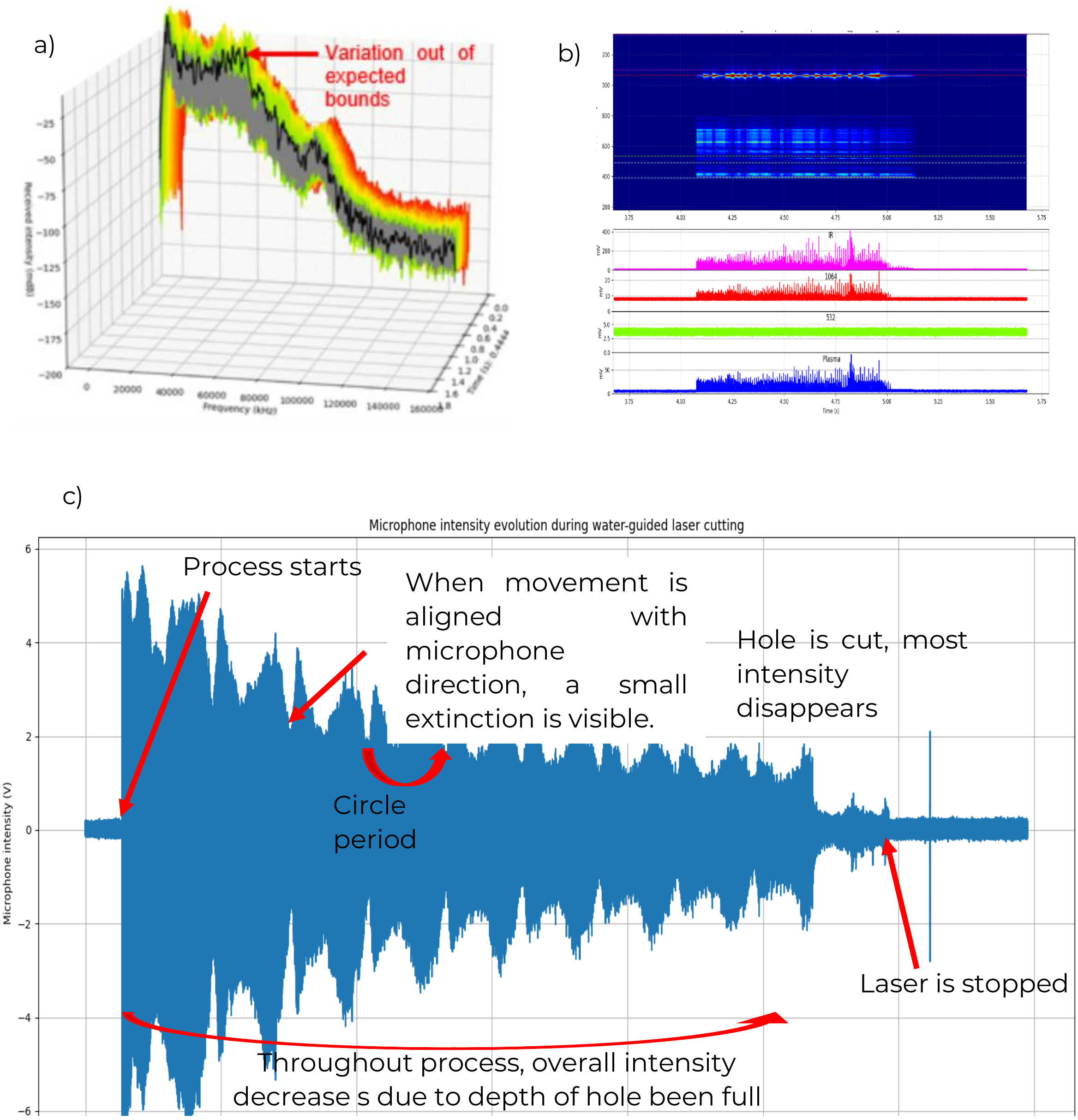

Figure 2: a) Capture of a process deviation at 0.45s in the process, where the acoustic emission (in black) show a peak at 40kHz different from the typical band (in grey); b) Comparison signals between photodiodes and spectrometer output from optical system; c) Acoustic measurement of WJGL process with clear breakthrough detection at 54s