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Genoa, 31 October 2019

Dear Editor,

Please find enclosed the electronic version of the original manuscript entitled “Acoustically-shaped laser: a machining tool for Industry 4.0” by Salvatore Surdo, Alessandro Zunino, Alberto Diaspro, and Martí Duocastella, to be considered for publication in ActaIMEKO. The manuscript belongs to the special issue of the 2019 IEEE International Workshop on Metrology for Industry 4.0 and IoT – Naples (Italy).

The high versatility of direct laser write (LDW) systems makes them ideal candidates as digital manufacturing tools for Industry 4.0. However, the inherent serial nature of an LDW can dramatically limit processing throughput and industrial scalability of this technology. To address these issues, we have recently developed a novel technology, named acousto-optofluidics or AOF, that allows boosting speed and design flexibility of, potentially, any LDW. The AOF employs acoustic standing waves in a liquid to produce either multiple beamlets or complex light patterns, which enable rapid laser material processing over indefinitely large areas, only limited by the stage travel range.

In the conference paper entitled “Acoustically shaped laser light as an enabling technology for Industry 4.0” (see supplementary files) our group performed a pilot study on the application of an AOF-based LDW station to industry 4.0. Specifically, we proved large-area (cm2) additive as well as subtractive direct manufacturing of user-selectable patterns of several materials of industrial interest. In this manuscript, we perform a new and significant step towards the realization of a cyber-physical system that exploits an AOF-LDW for high-throughput manufacturing of several materials. Specifically, we:

* Detail the design and implantation of the AOF cavity used to diffract and shape a laser beam.
* Perform an in-depth characterization of the AOF cavity by experimentally measuring its transfer function and the crosstalk between its X- and Y-axis.
* Show how an AOF-enabled system can be used for generating multiple laser beams or intensity patterns.
* Describe the architecture of the laser-based cyber-physical system (CPS) with AOF-functionalities for high-throughput manufacturing.
* Present a proof of concept of the cyber compotation functionalities of the laser-based CPS by monitoring the evolution of large-area ablation and the fidelity between the ablated pattern and its digital avatar.
* Extend the range of feasible patterns and material options of AOF-LDW.

Our new results open the door to the application of lasers to smart-factories with a high level of operational flexibility, productivity, and automation, thus helping to broaden the use of lasers for industry 4.0. As such, the paper should attract readers from both industry and academia. Our work is of high impact and intrinsically multidisciplinary, making it suitable for a journal such as ActaIMEKO.

Sincerely,

Salvatore Surdo and Martí Duocastella

Istituto Italiano di Tecnologia

Via Enrico Melen 83 Edificio B

Genova, 16152, Italy

e-mail: [salvatore.surdo@iit.it](mailto:salvatore.surdo@iit.it), [marti.duocastella@iit.it](mailto:marti.duocastella@iit.it)