SFB 1120

Annual report 2018

Subproject A1

Title

Control of geometry and metallurgy in laser beam microwelding by influencing the molten pool dynamics via locally and temporally adjusted energy input

Project management / processing

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Task definition

The aim in phase 2 of the subproject is to influence the precision-determining factors in laser beam microwelding determined in phase 1. The aim is to achieve an increase in weld seam precision in terms of geometric properties (welding depth constancy ≤ 1 %, welding depth control ≤ 5 µm) and functional quality (roughness Rz ≤ 10 µm, porosity ≤ 5 %).

The main focus of the first phase in the SFB 1120 was the investigation of cause-and-effect relationships and the detailed investigation of the coupling degree in the laser beam welding process.
In the further course of the project, these already developed analysis methods will be used to visualize the corresponding dynamics of the vapor capillary, the melt and the solidification. The main focus is on the investigation of the influence of the processing wavelength on the welding process.
In addition, the basic influences of a laser beam polishing process on the weld seam and material properties have been investigated in order to gain clues for a combined laser beam microwelding and polishing process.

Procedure

The experimental setup with two integrating spheres developed in phase 1 of the SFB1120 will continue to be used to realize precise spatially and temporally resolved measurements of the single head degree. In addition, by applying local power modulation to the welding process, the influence of the locally changing web speed on the coupling degree is determined. By adjusting the laser power over time, the fluctuation in the coupling degree can then be compensated.
In addition to local and temporal power modulation, laser beam sources in the visible wavelength range are used. For this purpose, two novel laser beam sources with a processing wavelength of 515 nm and 450 nm were put into operation at the Chair of Laser Technology and integrated into the existing test rigs. The increased degree of absorption in the welding process due to the shorter wavelength is used to achieve an increase in welding seam precision and process efficiency.

In addition to the conventional welding process, investigations on the additional laser beam polishing process will be carried out. The influence of the polishing process on the properties of the weld seam is investigated in order to generate parameter combinations that can later be used in the development of a combined process.

Results

The measurement of the degree of coupling as a function of the local power modulation has shown that the degree of coupling varies by up to ± 9% over the local orbital motion. (Figure 1)

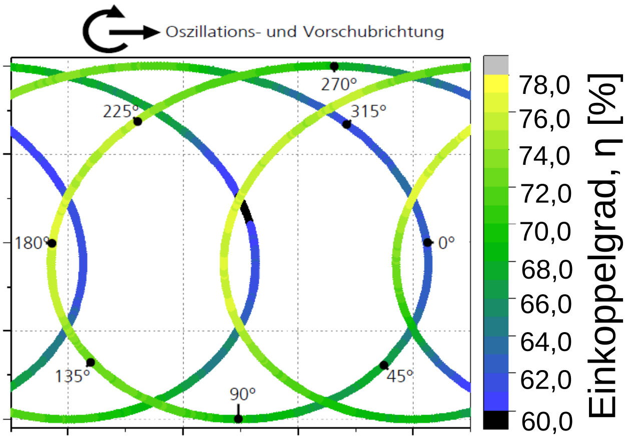

Figure 1: Change of the coupling ratio due to local power modulation

By means of a contrasting sinusoidal superposition of the power modulation, it was possible to reduce the fluctuations in the coupling degree to ± 2%. This has the effect of reducing the inclination of the weld seam in cross-grinding and thus increasing the weld depth constancy.

The results of the investigation of the wavelength influence on the coupling degree show an increase of the single head pelvic degree from 70-80% at 1064 nm to 85-95% at 515 nm on CuSn6 depending on the laser parameters. In addition to the absolute increase of the coupling degree by up to 25%-points, a reduction of the fluctuations of the conventional laser beam welding process without local power modulation from ± 4% to a few ± 0.1% can be seen. This reduction of the fluctuations ensures a more constant energy input and thus a more stable welding process.

Summary and Conclusion

The combination of local and temporal power modulation as well as the increased energy input by a shorter processing wavelength will be used in future investigations to further stabilize the energy input into the process and to increase the efficiency of the processes. In addition, in-situ investigations will be carried out in cooperation with the IFSW of the University of Stuttgart to investigate the influence of the machining wavelength on keyhole dynamics and keyhole geometry.
In Q4/2019 another laser beam source with a processing wavelength of 450 nm and an output power of 1 kW will be put into

operation. This laser beam source allows more detailed investigations of the influence of the wavelength as well as its use for laser beam polishing of copper materials. The results obtained will be used to develop a combined welding and polishing process. This process allows simultaneous welding and polishing to generate weld seams with high precision in surface finish.

Publication

A peer review publication was produced in 2018:

A. Aretz, L. Ehle, A. Haeusler, K. Bobzin, M. Öte, S. Wiesner, A. Schmidt, A. Gillner, R. Poprawe, J. Mayer, In-situ investigation of production processes in the large chamber scanning electron microscope, Ultramicroscopy, Volume 193, 2018, pages 151-158, ISSN 0304-3991;

Cooperation partners: A2, A5, A6, A8