Polymer-Metal 3D Printing using hybrid material extrusion - Pompey

Ines Dani[1], Philipp Klimant[2], Adam Wilczyński[3]

[1]Fraunhofer IWU, Chemnitz; [2] TU Chemnitz IWP, Chemnitz; [3]Omni3D Ltd, Poznań

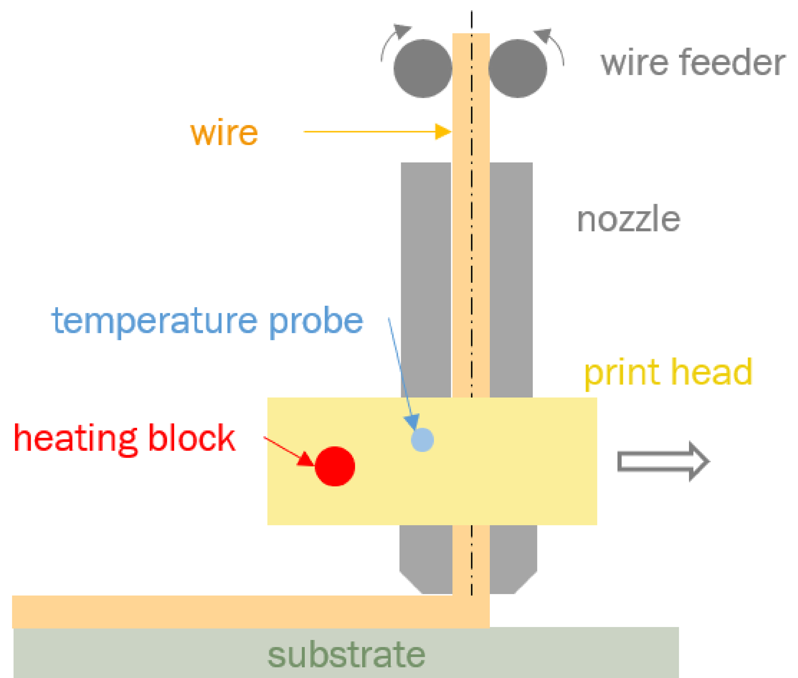
Fraunhofer IWU

TECHNISCHE UNIVERSITÄT CHEMNITZ

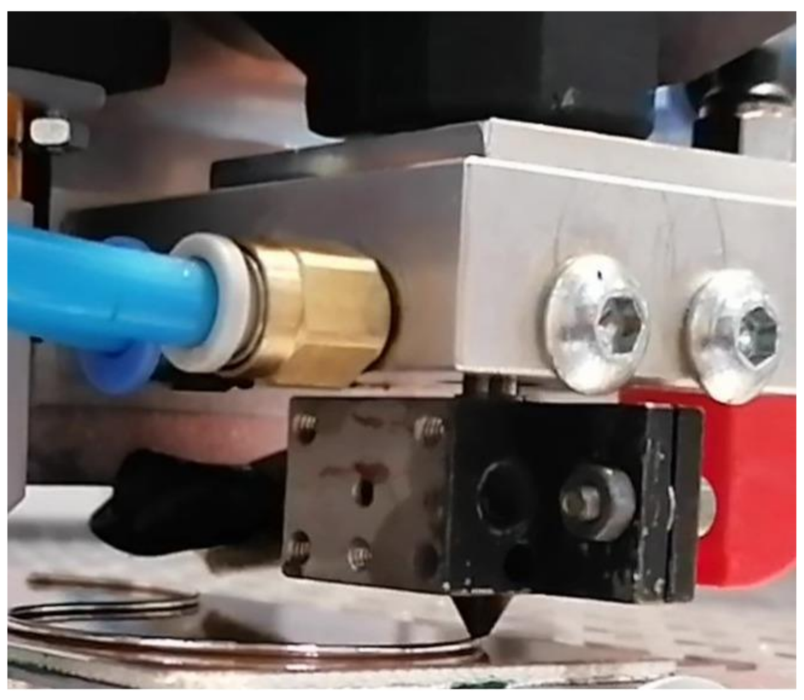
OMNI3D

Motivation

Innovative additive manufacturing (AM) technologies can produce custom products and open new possibilities for making electronic components. This integration of electronics into products increases performance and miniaturizes them. Multi-material technologies also allow electronic circuits and devices to be repaired, making them more durable. Today's challenges for additive manufacturing technologies in electronics include multi-material processing and quality control of multilayer structures, high productivity, and advanced assembly and interconnection techniques. The Pompey project focuses on AM processes to produce multi-material components with defined electrical properties. It investigates metal and polymer combinations designed to exploit additive manufacturing for innovative applications such as electronics. Its multi-material extrusion process makes miniaturized electronic components with improved performance by integrating electronics into the structure of the component. This process is characterized by low material and energy consumption and allows for the repair of electronic devices, contributing to a longer lifespan.



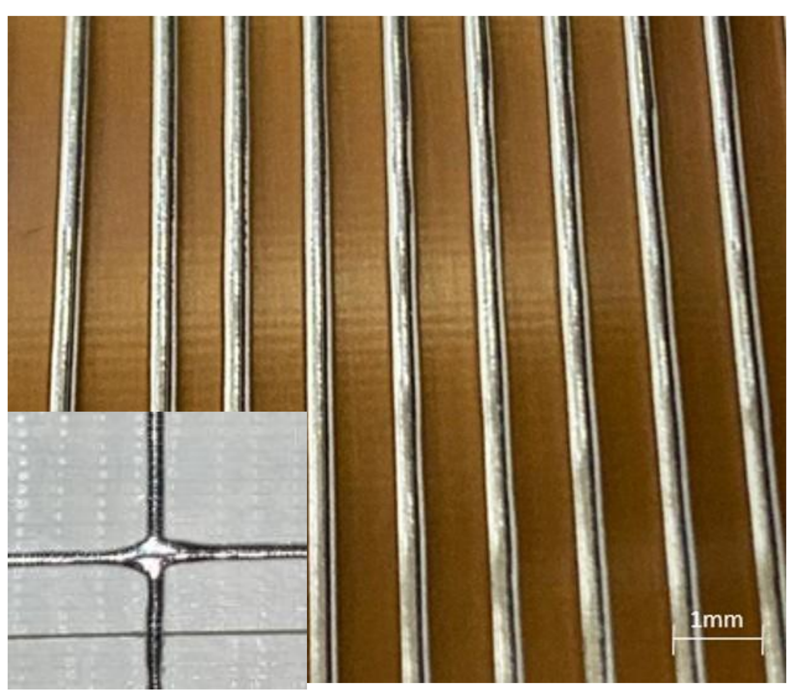
Scheme of material extrusion process



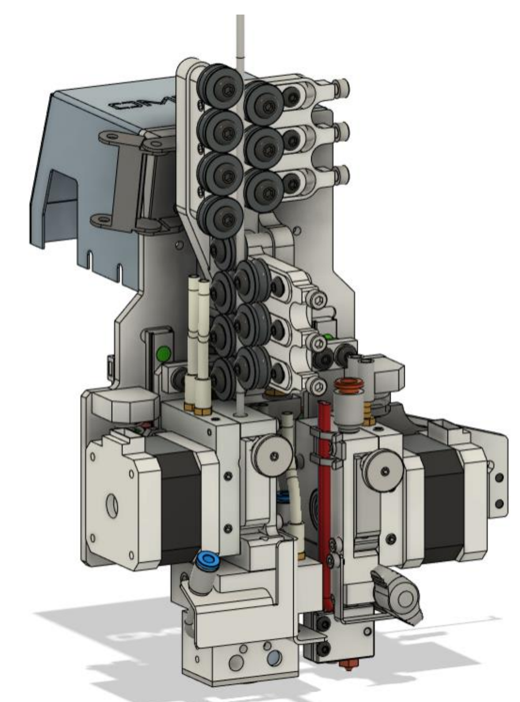
Metal printing process of tin alloys

Results

The investigations on metallic melt extrusion processes showed a principal analogy to the FFF process. Nozzle geometry and material have a decisive influence on the print quality and on the line geometry. Furthermore, the distance of the nozzle to the substrate and the inner diameter of the nozzle had a significant influence on the wetting behavior of the molten metal on the polymer substrate. Successfully varying of the parameters results in homogeneous lines and promising intersections. Depending on the inner diameter of the nozzle, line widths of 0.3 – 1.2 mm could be achieved.

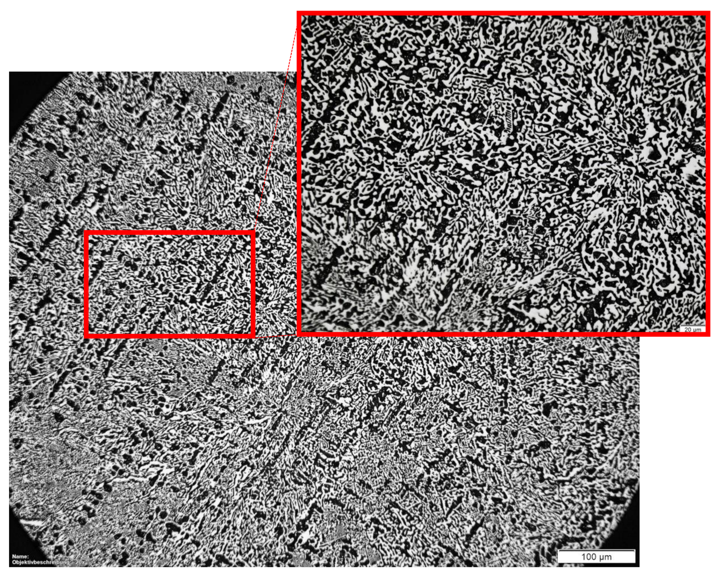


Printed lines on PE.

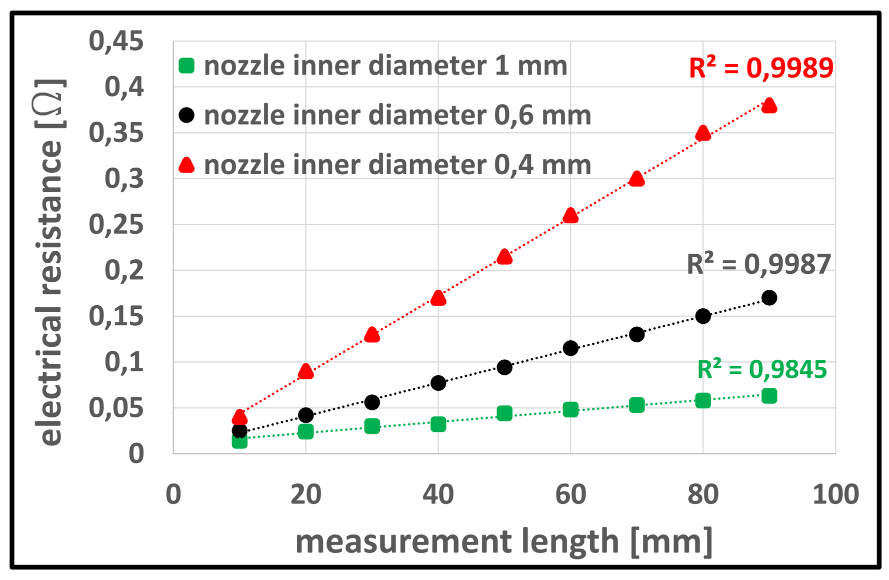


Hybride metal-polymer printing system.

The high quality of the lines produced was verified both by optical microscopy and by resistance measurements. A lamellar microstructure without structural defects was demonstrated for various print geometries. Furthermore, the linear increase in resistance over the entire length of the line indicates the absence of micro-voids or pores, in addition to geometric continuity.



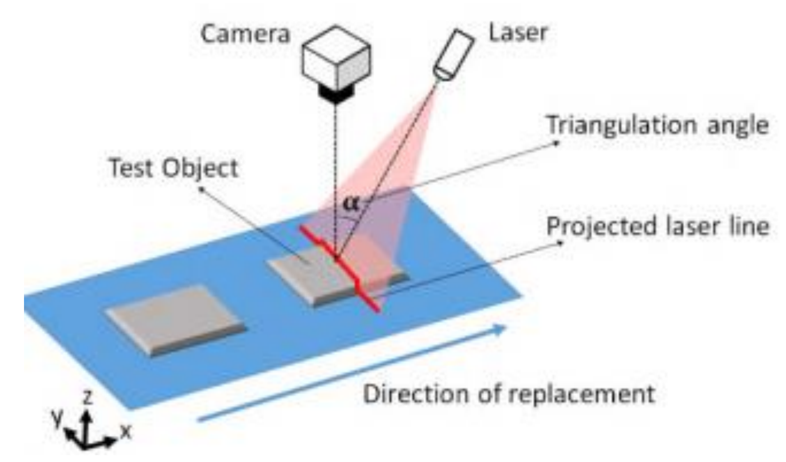
Optical microscope image of the printed line.



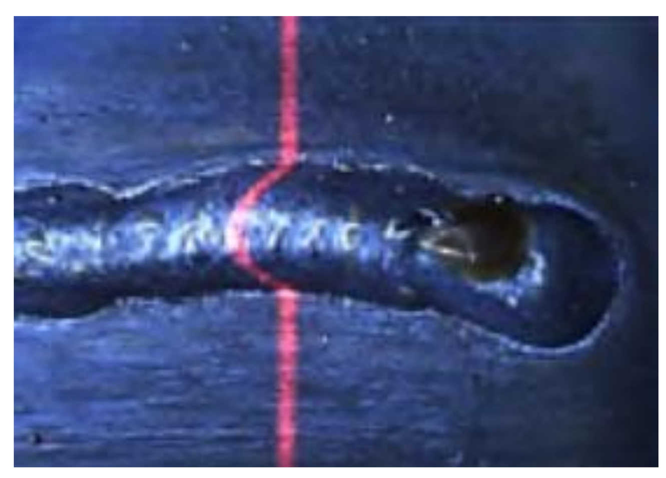
Electrical resistance measurements.

The findings from metallic melt extrusion were implemented directly in the development of the hybrid printing system. A dual print head system with integrated wire straightening unit was developed and successfully implemented.

Another aspect is the development of a cost-effective measuring system to automatically acquire 2D and 3D surface data of workpieces. This avoid errors and increase production robustness. Laser triangulation is suitable for 3D surface detection and optical flow for 2D. If textures are visible, optical flow provides high quality results for feed motion detection. Fine-tuning lighting and camera parameters plays a critical role. The quality of laser line segmentation has a significant influence on the accuracy of laser triangulation. A slight deviation of the segmented line is necessary for offset measurements.



Configuration of laser triangulation method.



Calibrated input image.

Conclusion

A melt extrusion process for low-melting metallic alloys (Bi58Sn42 and Sn97Ag3) was developed. The knowledge gained was then incorporated into the design and testing of the hybrid metal-polymer printing system. To increase process robustness, promising investigations were carried out to simultaneously capture 2D and 3D surface data of the workpiece.

Contact

Dr. rer. nat. Ines Dani
Tel. +49 371 5397-1948
ines.dani@
iwu.fraunhofer.de
Fraunhofer IWU
Reichenhainer Straße 88,
09126 Chemnitz, Germany
www.iwu.fraunhofer.de

Founded by the national partners of the european network M-ERA.NET

This measure is co-financed with tax revenue on the basis of the budget apporved by the Saxon state parliament.

NCBR National Centre for Research and Development