

# Additive micromanufacturing of metal microstructures

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The relentless drives to miniaturize components, and to customize and shorten production cycles set a welcoming stage for additive micromanufacturing ( $\mu$ AM) of metal microstructures. Here we present a  $\mu$ AM technology that is a combination of fluidic scanning probe microscopy and 3D printing [1, 2]. A plating electrolyte is locally delivered by a cantilever with a buried microchannel and a nano-nozzle, see Figure 1. The electrodeposition process enables a one-step, room temperature manufacturing method yielding a high-quality metal. Various metals like Cu, Ag, Au and Pt can be printed.

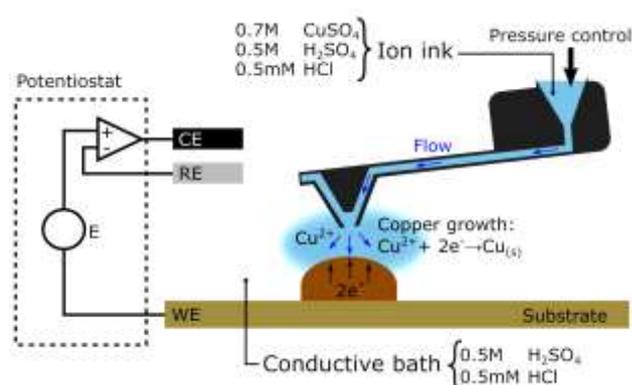
An object is built up sequentially out of 3D building blocks termed voxels. Accurate control of the air pressure used to expel the electrolyte from the nozzle enables tuning of the voxel diameter. Figure 2 exemplifies tuning using two different pressures to print a microconnector. The top and bottom parts are made at pressures of 30 and 200 mbar respectively, resulting in voxel diameters of  $\sim 3 \mu\text{m}$  and  $13 \mu\text{m}$ , respectively.

## References

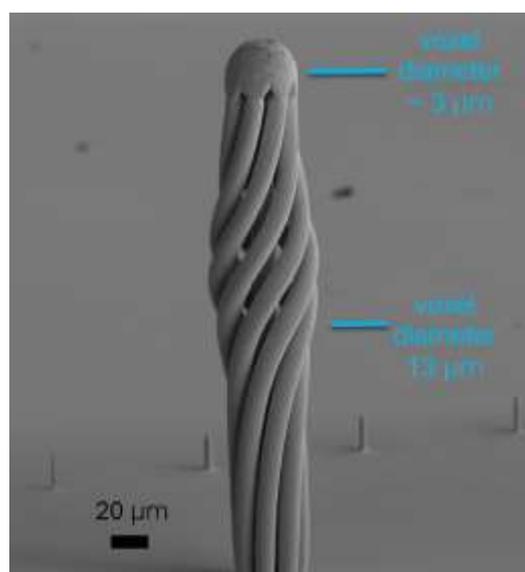
- [1] G. Ercolano, C. van Nisselroy, T. Merle, J. Voros, D. Momotenko, W. W. Koelmans, T. Zambelli, *Micromachines*, 11 (2020) 6.
- [2] G. Ercolano, T. Zambelli, C. van Nisselroy, D. Mometenko, J. Voros, T. Merle and W.W. Koelmans, *Adv. Eng. Mater.* (2019) 1900961

Other first-of-a-kind prints with  $\mu$ AM include decorative microstructures, 3D wire bonds and micro-springs with horizontal plateaus. The technology presented is industrially scalable and drives additive micro-manufacturing of metals well beyond its current state.

## Figures



**Figure 1:** Schematic of the  $\mu$ AM technology. A plating electrolyte for copper is locally delivered to print a voxel.



**Figure 2:** A copper microconnector made by  $\mu$ AM. The voxel diameter was chosen larger for the strands in the bottom section than for the dome of in the top section.