# 레이저 마이크로 소결 공정을 이용한 다공성 마이크로 구조물의 제작

# Fabrication of porous microstructures using Laser micro sintering

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## 1. Introduction

Micro mechanical structures such as micro gears, micro valves, etc. are gaining increased demand over the fields of automotive, medical, and microelectronic industries. Such microstructures made from silicon or polymeric materials are readily manufactured by the aid of MEMS or injection molding techniques. However, these structures are usually brittle under mechanical stress. For such applications where high mechanical reliability and thermal stability are required in micrometer scale systems, metallic and ceramic materials are widely used.

Besides fully dense solid micro parts, parts made from metallic and ceramic materials with a certain porous morphology are increasingly applied in numerous applications ranging from traditional catalytic, filtrating applications to orthopaedic applications, nowadays[1]. These porous structures have been produced in a number of ways, most in which micro grade powder is sintered in an oven producing structures with loose interconnections[2]. This is most often referred to μPIM (micro powder injection molding). However, μPIM has certain drawbacks on the mass production and controllability of the output that can be obtained. It requires a negative mold for each geometry and sinter conditions and resulting porosity is often hard to correlate.

In this research, laser micro sintering (LMS) is considered as an alternative method to produce porous metallic & ceramic microstructures. LMS is a free form 3D printing technique which utilizes a Q-switch laser to produce porous micro structures[3]. A simple porous needle with an aspect ratio of 1:50 was produced with LMS and μPIM. It has been shown that LMS is a promising candidate for producing porous metallic structures with better controllability over production parameters and shorter production time.

## 2. Experimental

μPIM and LMS were performed in different sintering conditions to produce a simple porous needle structure with an aspect ratio of 1:50. The powder used for both processes was a 10μm grade tungsten powder. The μPIM process was done at Pimtech GmbH, Austria[2]. The tungsten powder was mixed with a binder material which then was injected in a negative mold under high pressure. After subsequent debinding and sintering processes at temperatures of 450 and 1600 degrees, respectively, final sinter parts were obtained.

The LMS process was done at the laser institute of Mittweida, Germany[3]. Once the geometry was 'sliced' into sub-layers with a thickness of 10um, each sub-layer was then irradiated by a Q-switched Nd:YAG-las er (λ=1064nm) with accordance to the STL file implemented on the laser optical device sintering the underlying tungsten powder bed. After each layer was sintered, a new powder layer was spread on top via the newly devised powder layer device developed at the laser institute of Mittweida.

The whole process of LMS has been carried out in an inert atmosphere to prevent burning of powder.

### 3. Results

The micro porous structures made using μPIM and LMS are shown below (Fig. 1). It shows the magnified image of the tip of the proposed needle structure. With μPIM, the maximum sharpness one could obtain was not bigger than 300μm, whereas in LMS the least achievable diameter of the needle tip was around 100μm. To achieve more sharper tips, one could perform electrochemical etching.

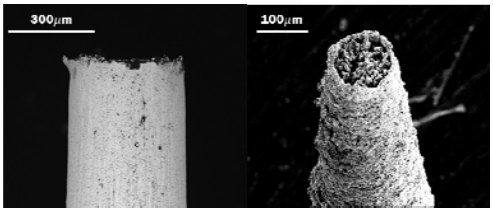


Fig. 1 Magnified SEM image of Micro tips fabricated by PIM(left) and LMS(right)

Fig. 2 shows the SEM image of the surface of the structures made by PIM and LMS

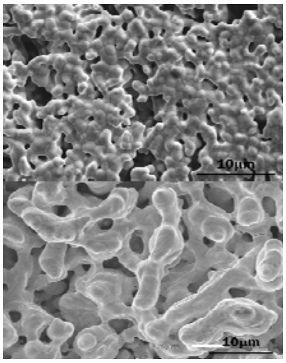


Fig. 2 SEM image of surface of micro parts fabricated by PIM(left) and LMS(right)

The average pore sizes and pore density is both smaller and higher in the μPIM case, due to the fact that μPIM was done under an industrial standard process to produce solid parts whereas LMS lacked the sufficient 'packing' of powder to produce more dense structures. Afterwards, the micro parts were tested for open porosity by checking the infiltration of water from the bottom surface of the needle and in both microstructures fabricated by LMS and PIM, water was infiltrated onto the top surface (Fig. 3).

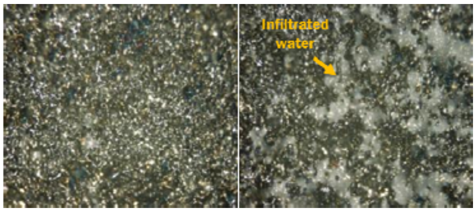


Fig. 3 Infiltration test to check open porosity

### 4. Conclusion

It has been seen that laser micro sintering can be a promising tool for producing free standing 3D micro structures. Compared to micro powder injection molding, Laser micro sintering doesn't require a negative mold as in μPIM which is usually very expensive to manufacture. And by the aid of simple 3D modeling, one can virtually produce any free-form 3D microstructure and modify and produce new structures by simply modifying the 3D model. This is especially more intriguing in cases where several micro-parts with slightly different geometrical parameters have to be produced within a short time.

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