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Scan Line Patterning: An Efficient Approach to Achieve Periodic Open Cell Structures in Selective Laser Melting

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The adaptation of additive manufacturing for chemical flow reactors has recently gained momentum as the manufacturing methods become more advanced and manufacturing equipment is increasingly affordable.[1] Periodic open cellular structures (POCS) from additive manufacturing have lately received growing attention. Compared to randomly structured substrates such as metal foams, POCS offer an ordered structure, which promises improved flow control and homogeneous flow profiles at comparably low pressure losses. However, the achievable minimum cell size is still limited to few millimeters, which results in low specific surface areas compared to conventional metal foams.[2] Moreover, finely-resolved 3D models that define these POCS require an extensive amount of computing power with increasing resolution and corresponding large file sizes. A scale-up to industry-relevant sizes is therefore limited. Consequently, the direct definition of micro-features in large 3D models is infeasible, as STL files that directly define POCS will reach gigabyte sizes for reactors with outer dimensions of few centimeters and with POCS cell sizes of few millimeters and strut sizes in the millimeter range.

We have recently shown that the porosity and thus the specific surface area in selective laser melting (SLM) can be globally controlled via the laser energy density.[3] In this work, we now present a method to create defined microfeatures, without the need to explicitly define the features in a CAD model, thus avoiding large file sizes. Our method requires no definition of micro-features in 3D models such as STL files, but rather makes use of the scan lines, i.e., the path with which the laser proceeds through the powder bed. By actively controlling the scan line pattern of each layer, repeating structures are created implicitly. The scan line pattern is defined in the print job file, requiring only a 3D model of the macrostructure, which may be as simple as a cylinder, thus only amounting to a file size of few kilobytes.

As example for the simplest form of POCS, a cubic structure is created with cell sizes as small as 400 µm and strut thicknesses of approximately 100 µm. The resulting structures are analyzed by reconstruction of 3D models from micro-computed X-ray tomography.[4] From the model, the strut thickness, cell size and specific surface area can be derived, which presents as beneficial compared to other imaging methods such as SEM, where the analysis is limited to the surface.

Figure 1 presents a model POCS structure, consisting of cubic cells with a cell size of 800 µm. The strut sizes and specific surface area are approximately 120 µm and 5.6 x 10^3 m^2/m^3, respectively, which is well in the range of commercial metal foams.

The presented method therefore shows great promise to propel the design of highly active, open-porous reactor systems to industrially relevant scales with small feature sizes that have sparsely been reported in literature so far.

Participation

In-Person

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