Examination of the Geometry-dependent Anisotropic Material Behavior in Additive Layer Manufacturing

Fraunhofer IWU

Projektgruppe
Ressourceneffiziente mechatronische
Verarbeitungsmaschinen

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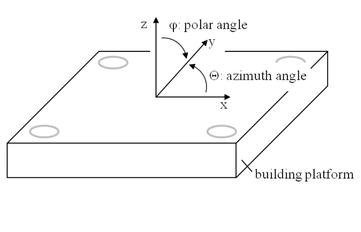
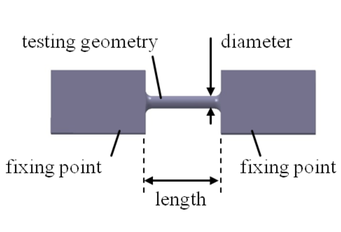
Due to the producible geometric complexity, additive layer manufacturing (ALM) processes show a high potential for the production of lightweight components. Especially mesoscopic approaches, like honeycombs or lattice structures, exhibit very advantageous mechanical properties like stiffness or strength combined with low masses. To achieve an optimum structure, a regular build-up out of equal elementary cells is not ideal. Rather, an adjustment of the course of the structure and its material filling degree has to be done. Therefore, detailed knowledge about the material behavior of additive manufactured components is necessary. Especially for lightweight structures, these properties are affected by anisotropy and geometry dependent influences. These aspects have a severe influence on the mechanical properties of basic elements of mesoscopic patterns.

Testing geometry and orientation

- non-proportional struts
- strut-form similar to DIN 50125 form E
- testing parameter
  - angle (polar and azimuth)
  - strut length
  - strut diameter

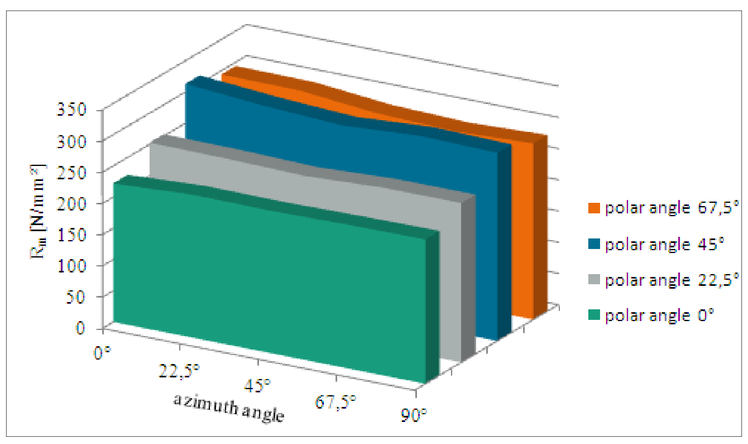




Azimuth and Polar Orientation

Results

- polar angle has significant influence on tensile strength
- azimuth angle does not show considerable influence
- 90° struts show massive geometrical defects



transversal anisotropy with constant mechanical properties for azimuth rotation

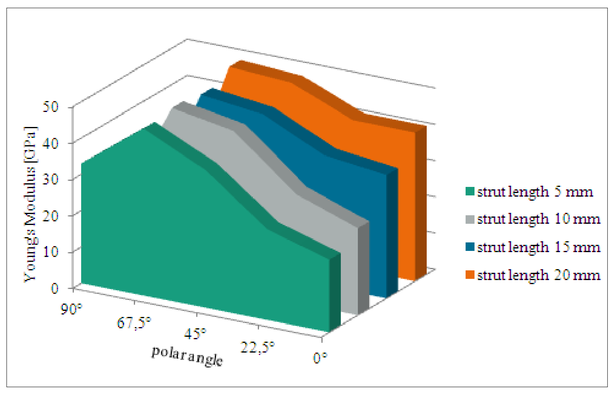
Length

Testing geometry

- polar angle: 0°, 22.5°, 45°, 67.5°, 90°
- length: 5 mm, 10 mm, 15 mm, 20 mm

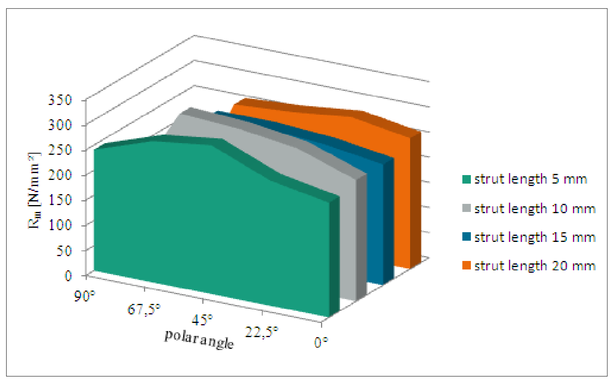
Young s Modulus

- drop for high angles observable
- for lower angles no influence of the struts length will appear, as it can be seen for 67.5°, were no notches do appear



Tensile strength

- better behavior of short struts is observable for horizontal specimen
- no tendency concerning correlation of length and tensile strength observable for steeper struts



it is assumable, that the length does not have severe influence on the mechanical properties of struts in lattice structures expects for horizontal struts

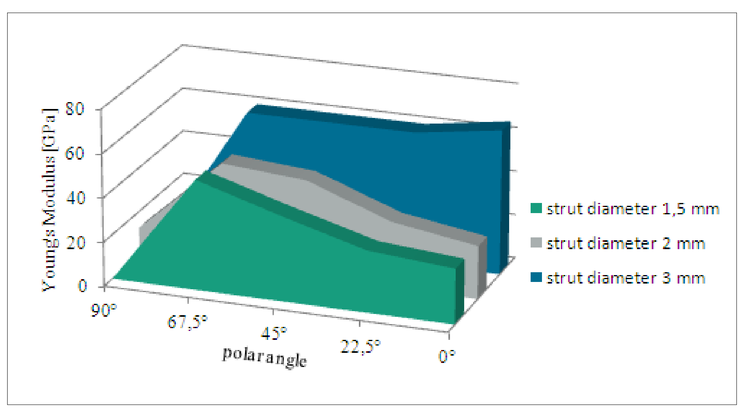
Diameter

Testing geometry

- polar angle: 0°, 22.5°, 45°, 67.5°, 90°
- strut diameter: 1.5 mm, 2 mm, 3 mm

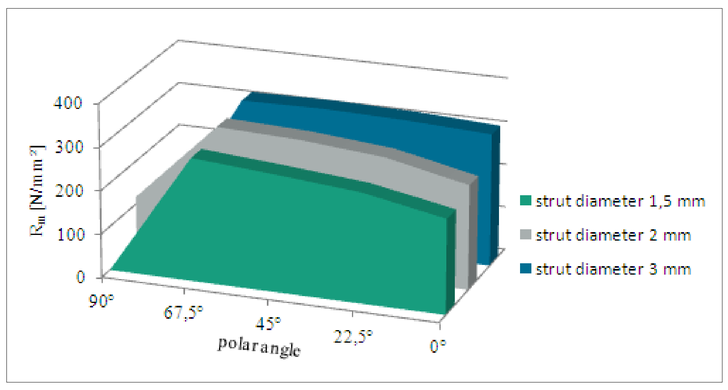
Young s Modulus

- dependency can be explained with the appearance of notches on the struts surface
- Young's modulus for thin struts is severely below the one for thick struts



Tensile strength

- analogue results for the tensile strength



for higher surface to volume ratios, notches have a greater influence on the material properties of the whole strut and worsen its behaviour

Implementation into a Calculation Tool

The presented results are to be used for the determination of the mechanical properties of lattice structures. Therefore, a software based material model was implemented, to determine the mechanical properties of each strut from its diameter and the coordinates of its starting and ending points. For this purpose, mathematical functions are determined from the measurement data, which represent the respective correlations.