Elevated Region Area Measurement for Quantitative Analysis Of Laser Beam Melting Process Stability

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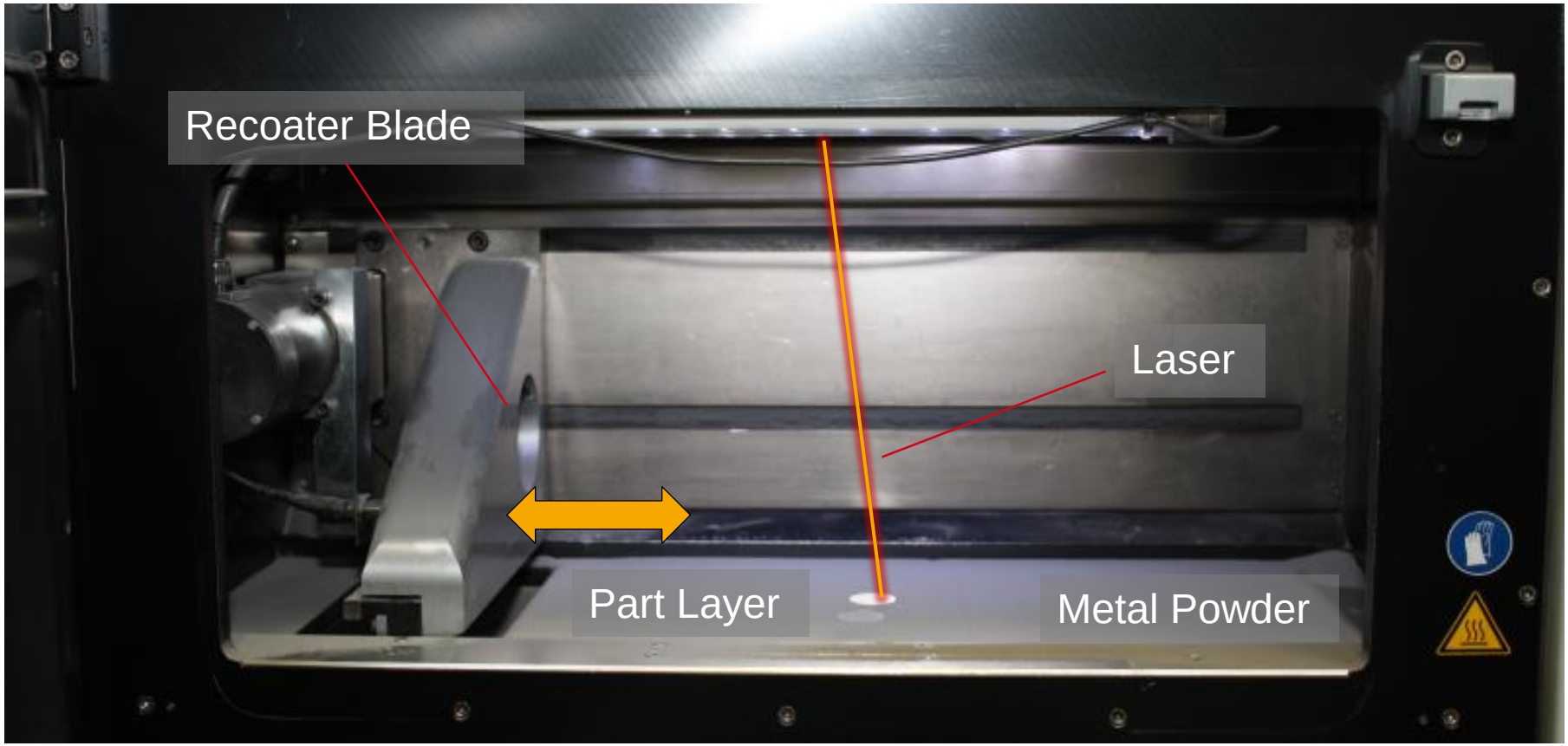
Introduction

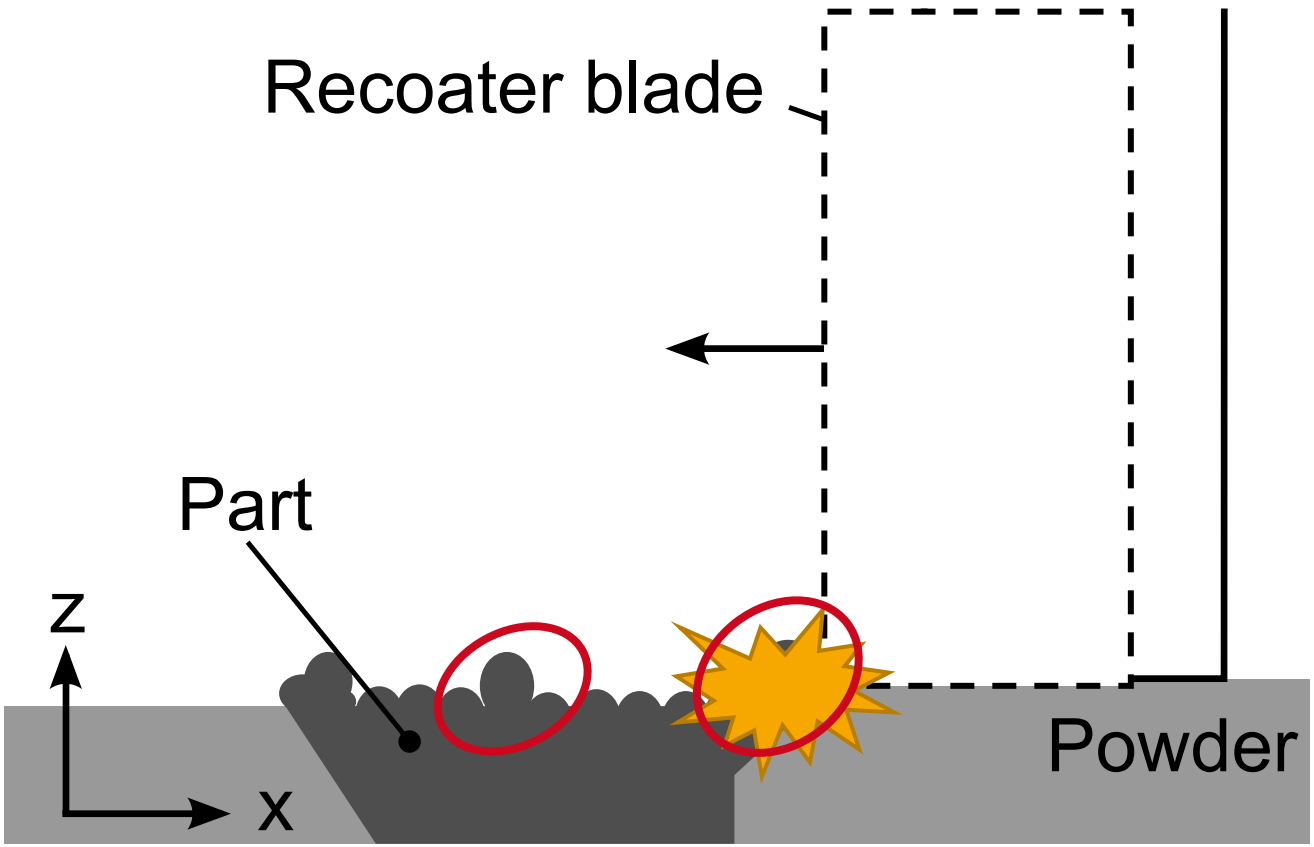
EOSINT M 270 (EOS GmbH, Germany)

Introduction



Process Chamber

Elevated Part Regions



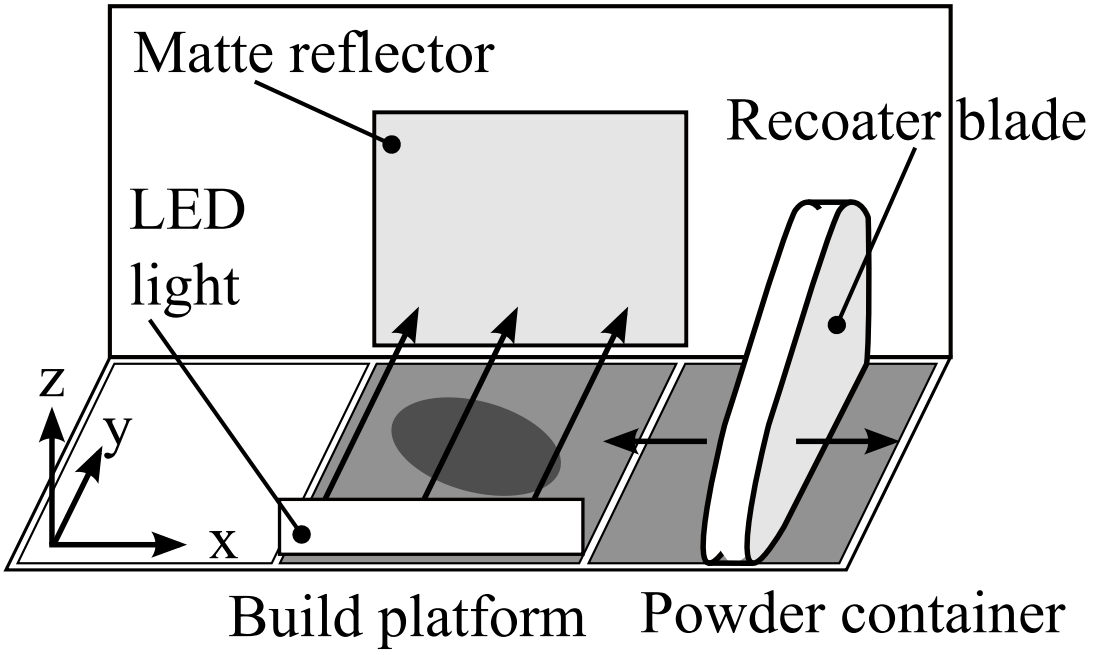
may damage part/recoater blade and cause jammings

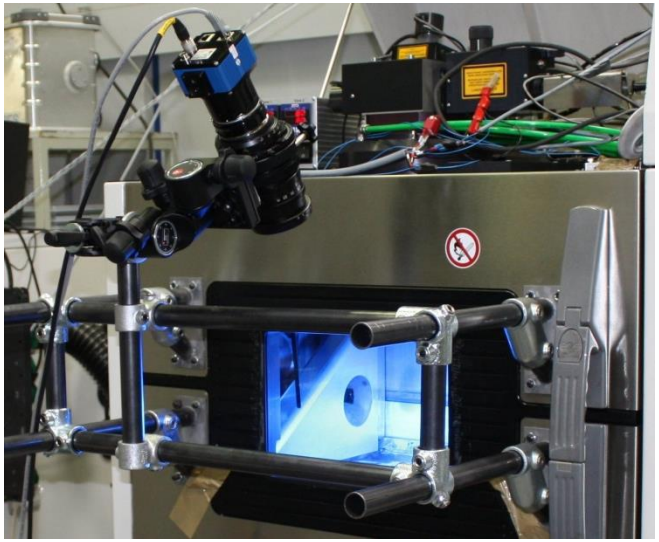
➢ **major risk to process stability**

Outline

- ✓ Introduction
- Method
  - Powder Bed Imaging
  - Detection of Elevated Regions
  - Elevation Analysis
  - Visualization
  - Experimental Build Jobs
- Results
- Discussion
- Conclusion

Powder Bed Imaging

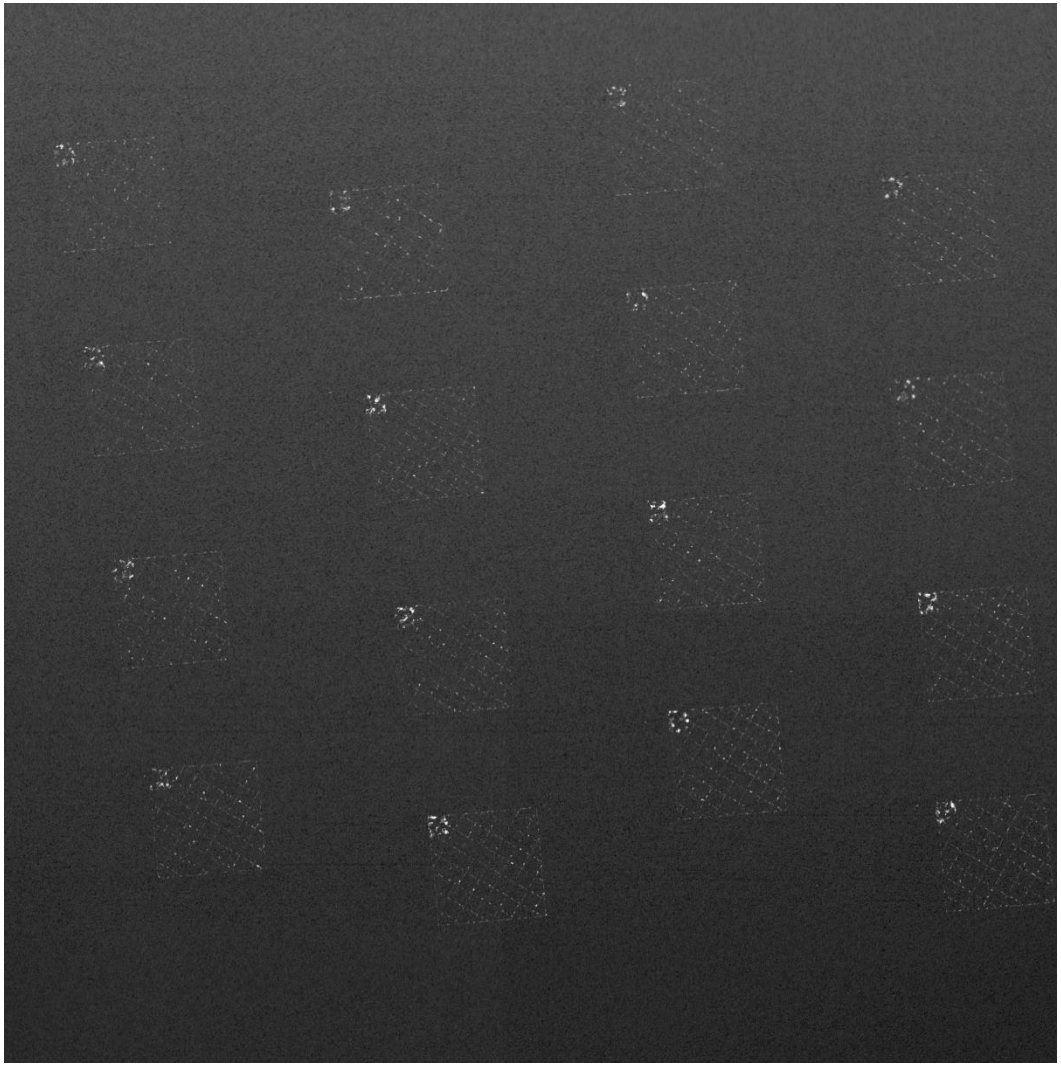




29 MPixel camera (SVS29050, SVS-VISTEK, Germany)
Hartblei 120 mm tilt and shift lens (Hartblei, Germany)

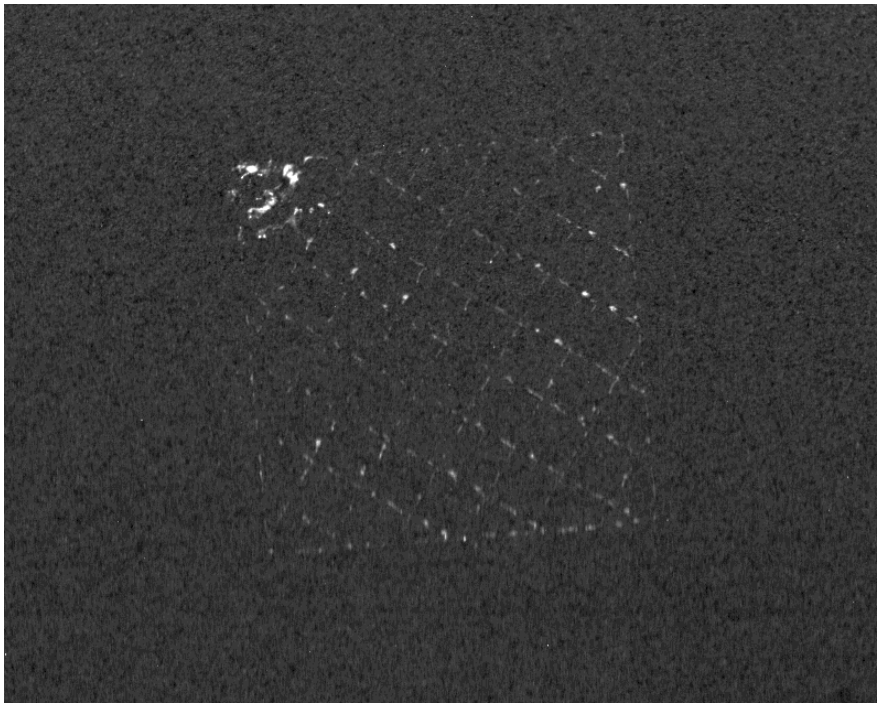
Kleszczynski et al.
Error Detection in Laser Beam Melting Systems by High Resolution Imaging
Solid Freeform Fabrication Symposium, **2012**

Powder Bed Layer Image



Detection of Elevated Regions

Compute threshold from powder bed image, segment elevated regions

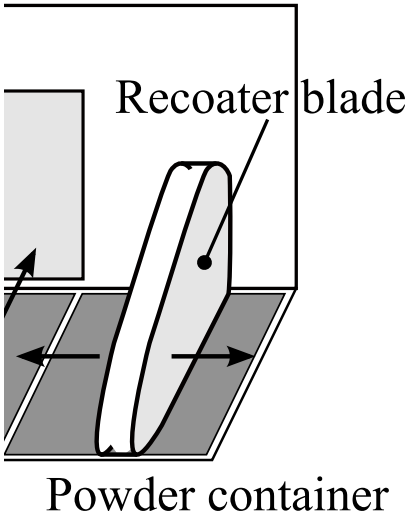


Note: small regions (≤ laser diameter) are ignored

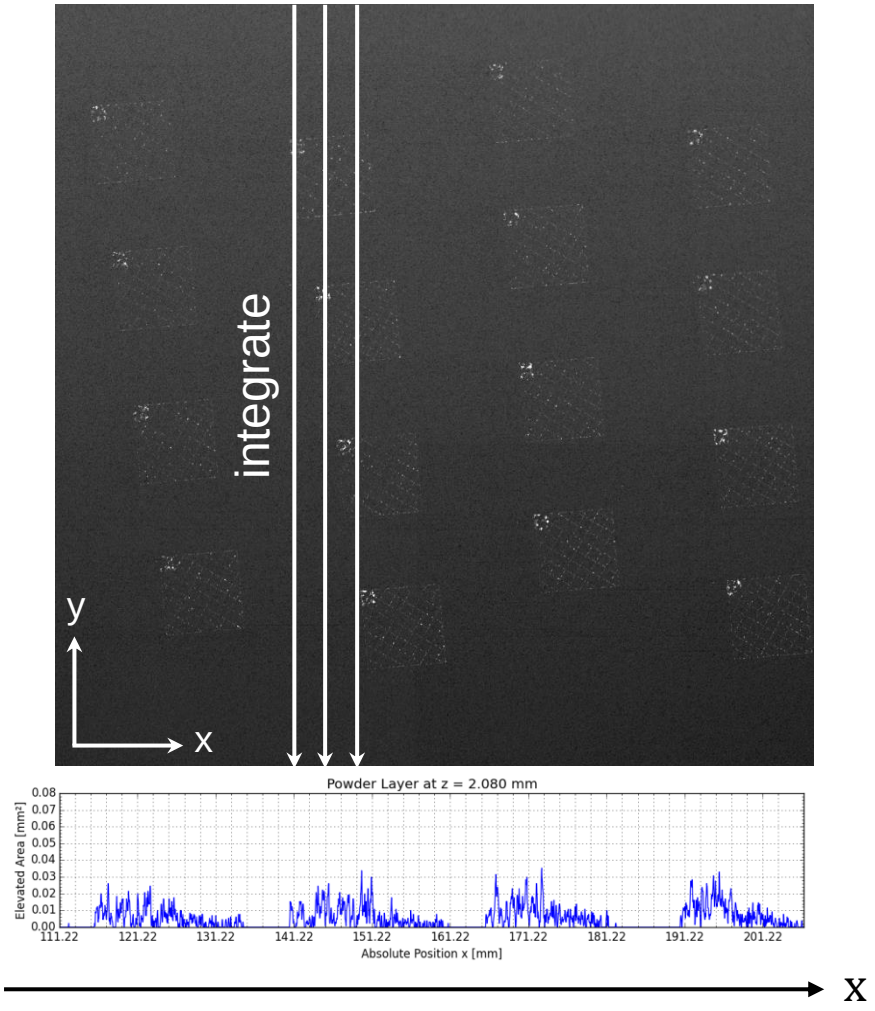
zur Jacobsmühlen et al.
High Resolution Imaging for Inspection of Laser Beam Melting Systems
IEEE International Instrumentation and Measurement Technology Conference (I2MTC), **2013**

Elevation Analysis

- Recoater blade moves in x-direction



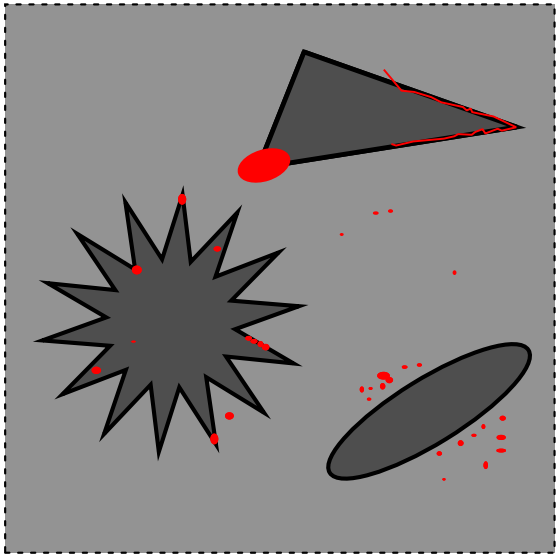
- Integrate all elevations at any position x_0 to obtain area [mm²] as measure of severity



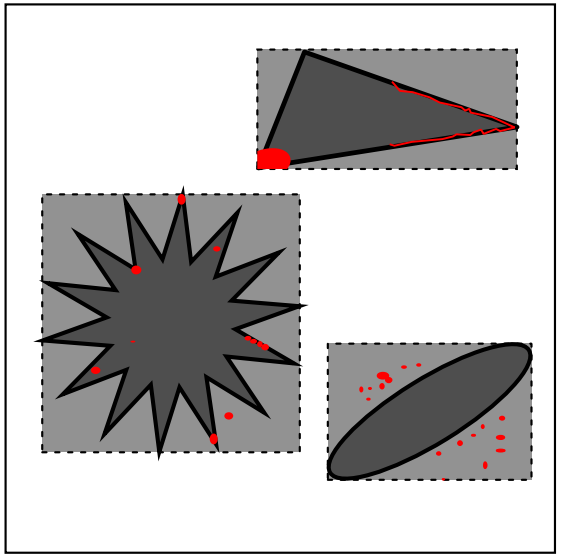
Kleszczynski et al.
Improving Process Stability of Laser Beam Melting Systems
Fraunhofer Direct Digital Manufacturing Conference, **2014**

Elevation Analysis

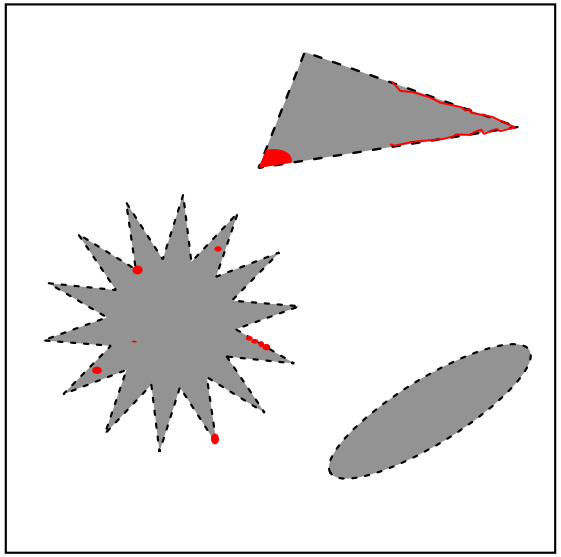
Different Analysis Regions for Stability Evaluation



Entire layer



Part *regions*
(bounding boxes)



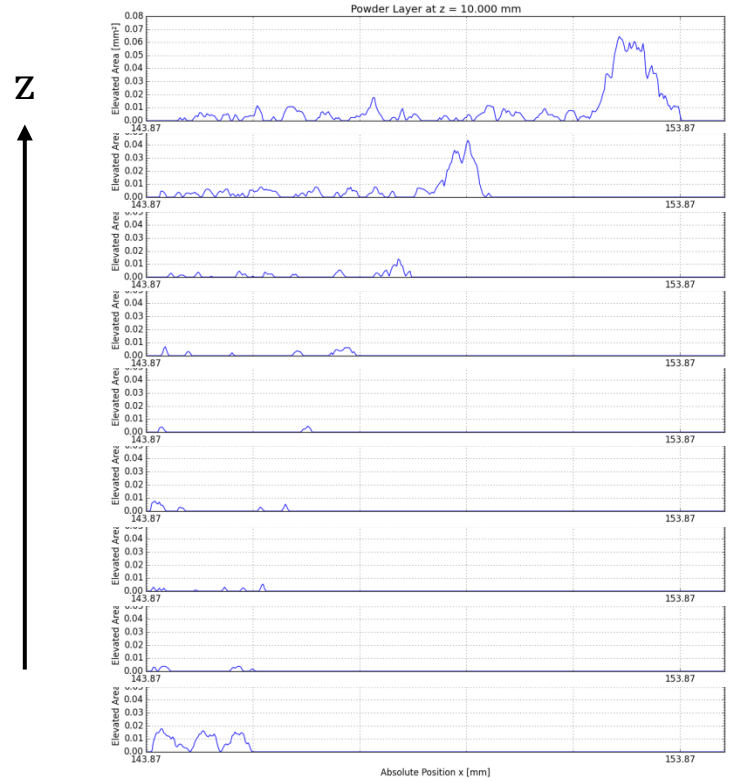
Part *area*
(layer geometry)

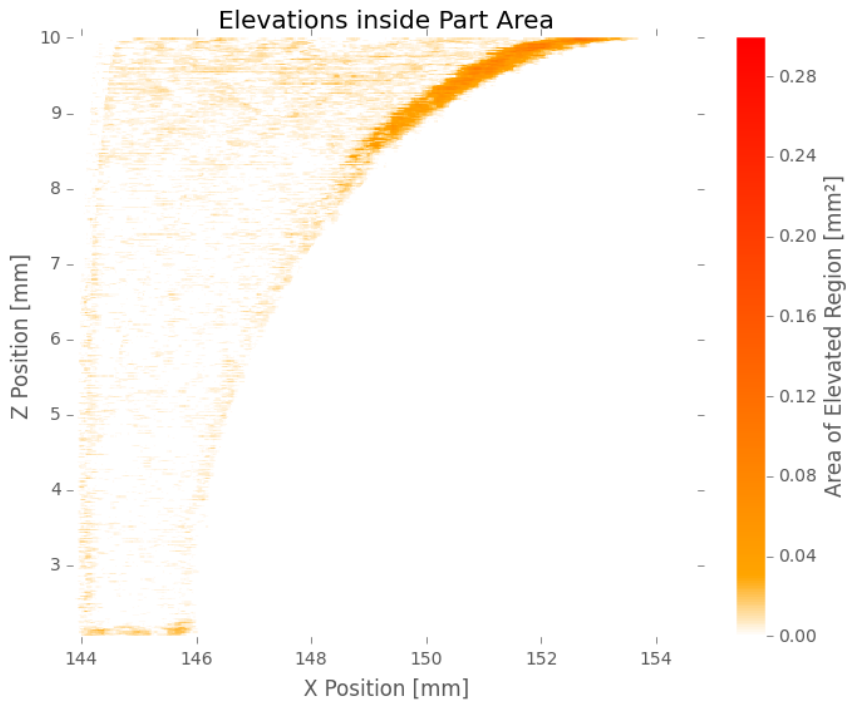
➢ Evaluation of:		
process stability	**parts and supports**	**parts**
➢ Optimization of:	support parameters	process parameters, e.g. energy input

Visualization

Visualization for Single Part

- Compute measurements over x for all layers
- Combine stacked measurements and use color-coding for elevated area





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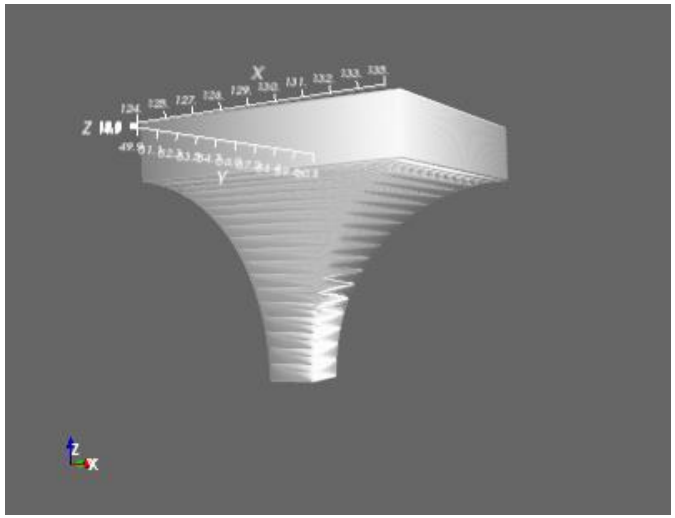
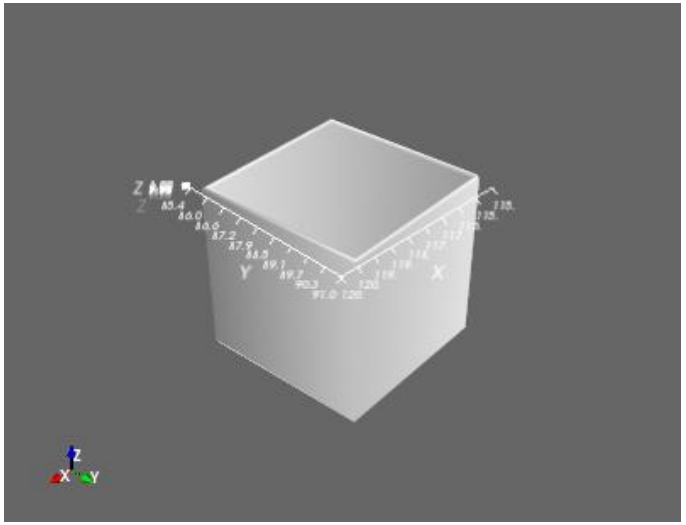
Experimental Build Jobs

Varied Support Structure Configuration

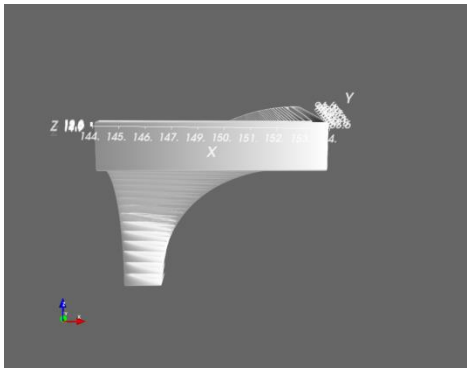
Job A
- Material: Hastelloy X
- 16 parts with overhanging geometry

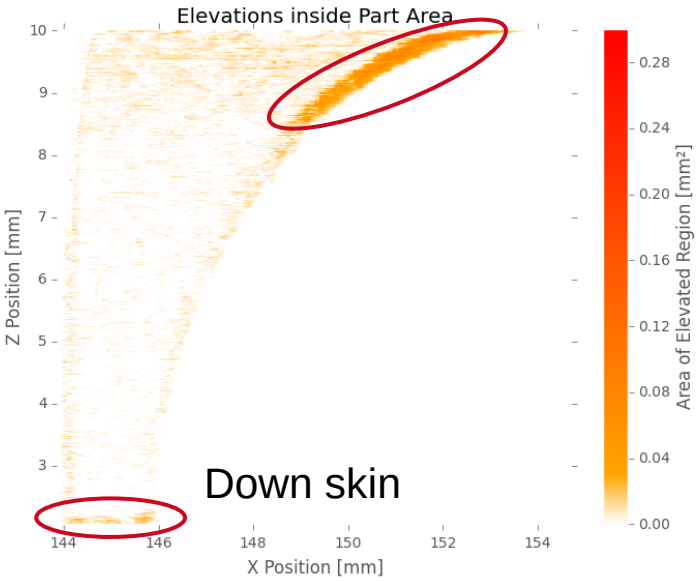


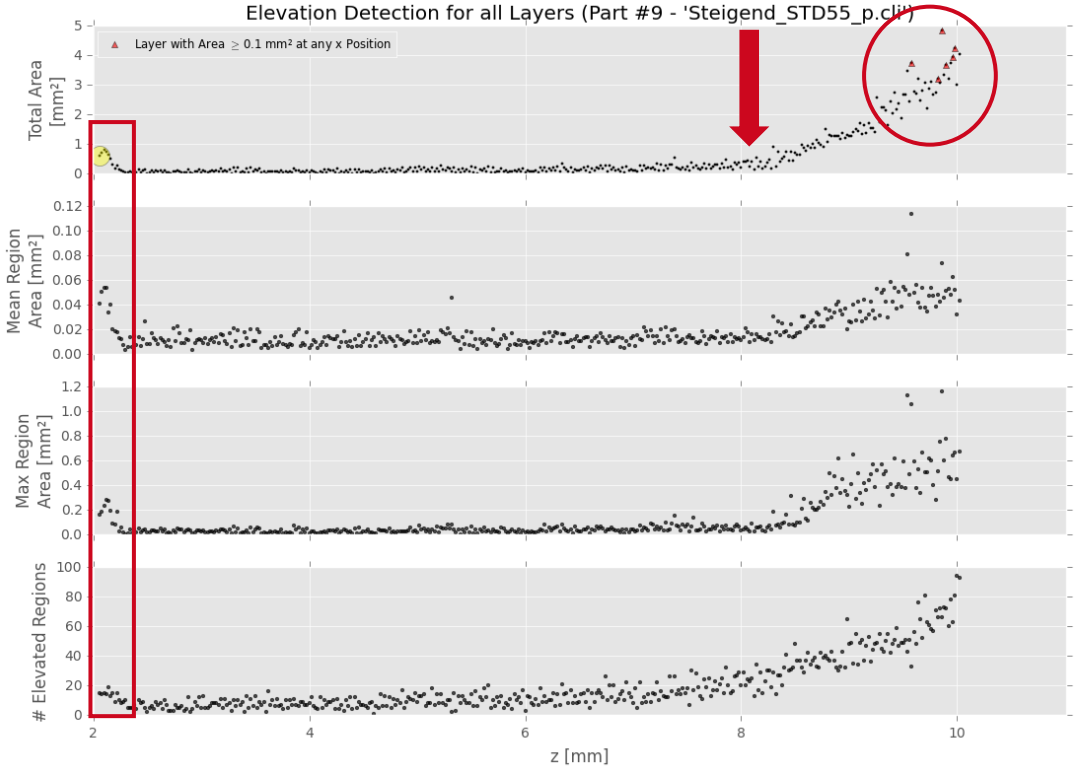
Job B
- Material: Hastelloy X
- 25 cubes



Results Job A: Overhanging Geometry







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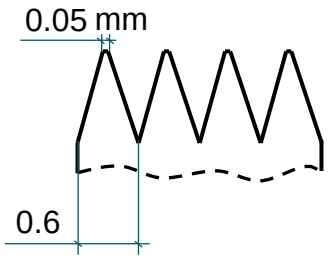
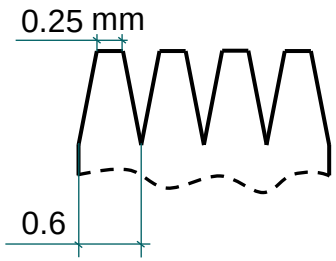
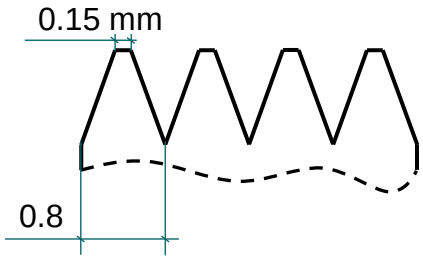
Results Job B: Cubes – Part Region

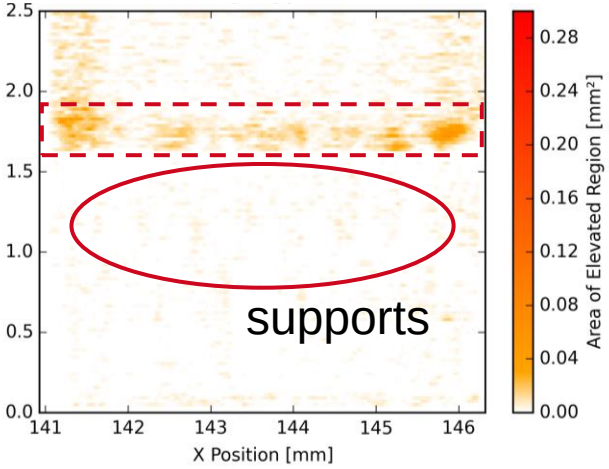
Comparison of Different Support Structure Configurations

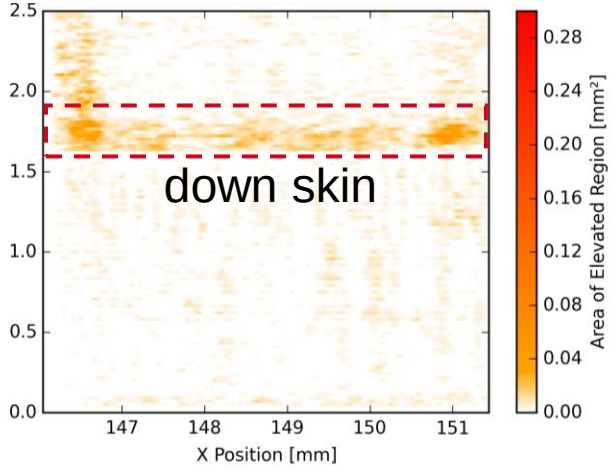
- Identical teeth height 0.9 mm

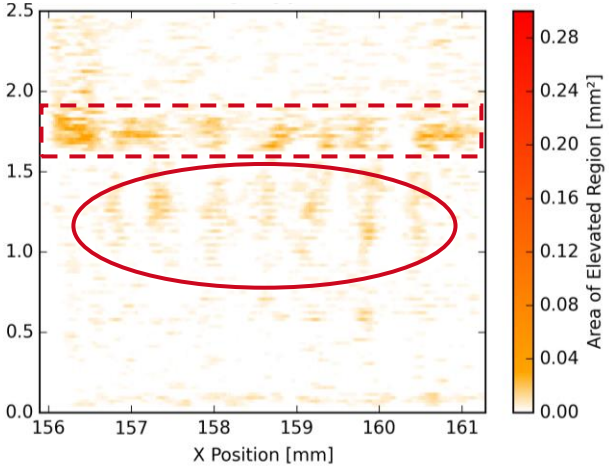








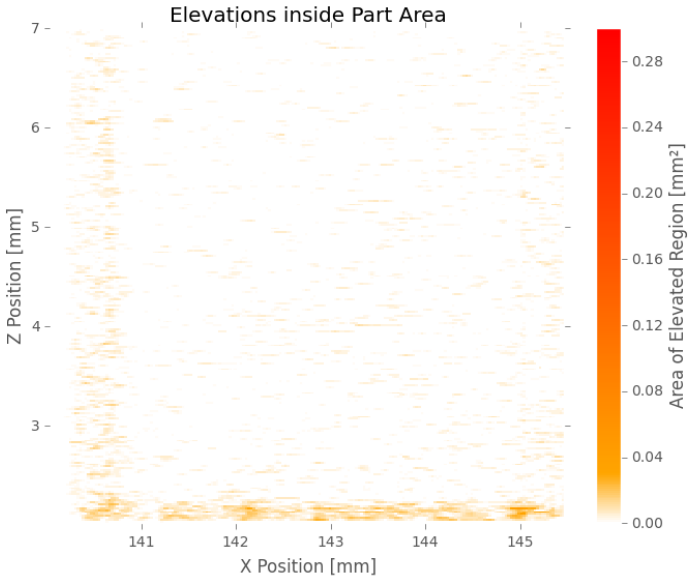


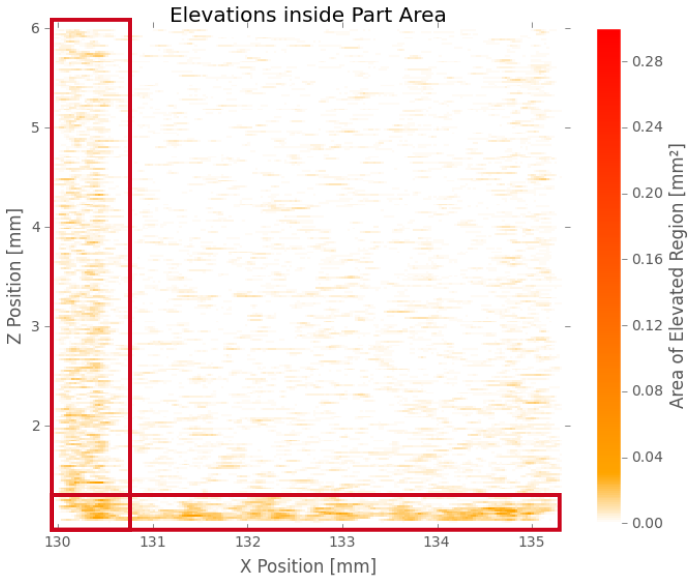


Results Job B: Cubes – Part Area

Comparison of Elevations inside Part

- Note: parts start at different z positions





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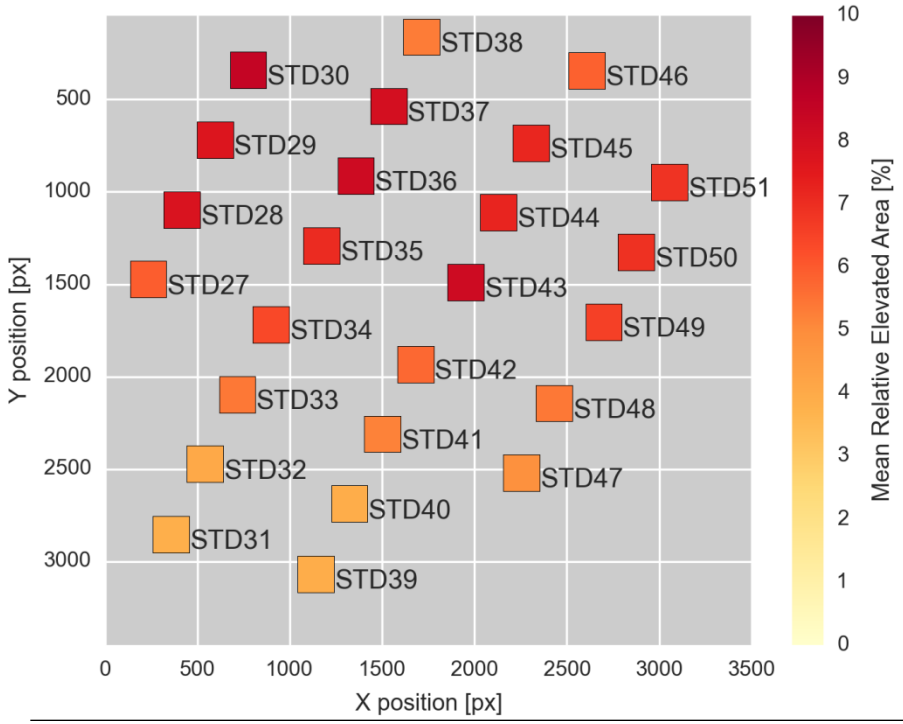
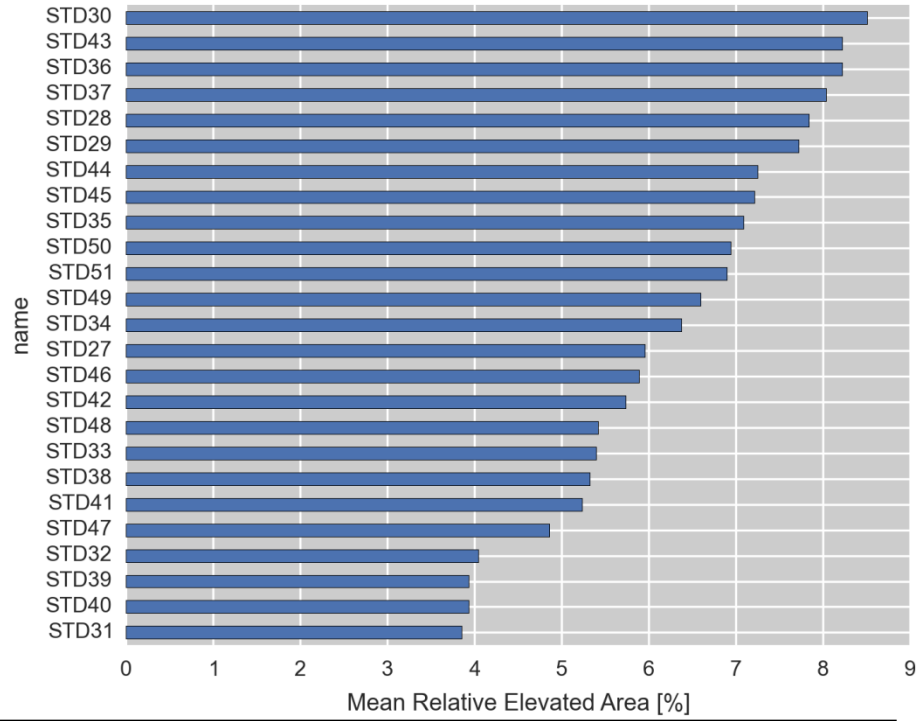
Results Job B: Cubes – Relative Elevated Area

Stability Ranking of Parts

- Compute ratio of elevated area and part area for each x position
- Average relative elevated area **over all layers**

➢ Quick overview and identification of critical part configurations





Discussion

- Color-coding uses threshold for critical elevations, $A_{\text{critical}} = 0.1\text{mm}^2$, from accelerometer measurements in [1]:
  - White to orange for $A \leq A_{\text{critical}}$, orange to red for $A_{\text{critical}} < A(x,z) \leq 3A_{\text{critical}}$

➢ Validation of critical threshold desirable to avoid false alarms for stable build jobs

- Differences of relative elevated area in ranking are very low
  - Color scale might exaggerate difference between parts

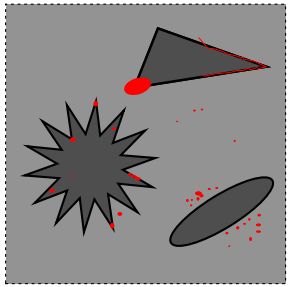
➢ Define boundaries for expected values under stable and unstable conditions to provide recommendations for stability optimization

[1] Kleszczynski et al.
Improving Process Stability of Laser Beam Melting Systems
Fraunhofer Direct Digital Manufacturing Conference, **2014**

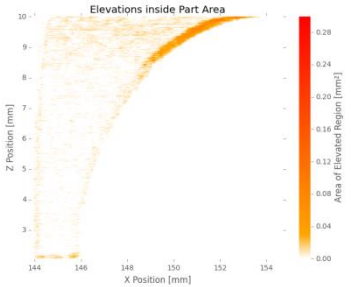
Conclusion

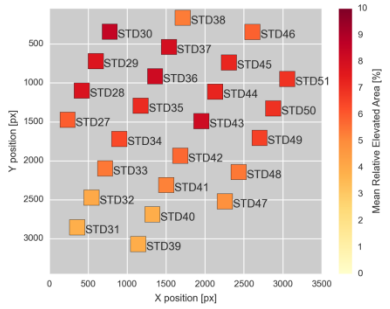
Summary

- Elevations of part regions pose a major risk to build reliability of laser beam melting (LBM) processes
  - Collisions between recoater blade and part
- Elevations can be detected in powder bed images



✓ Measurement for entire layers, part regions and part geometry
✓ Visualization for all layers in x/z-plot
✓ Ranking of part stability using relative elevated part area





Future Work

➢ Identify and validate boundaries for developed measures to provide guidelines in the build design phase

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http://www.lfb.rwth-aachen.de/en/research/industrial/bigs/
(or scan QR code)

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