

Development of a test method for characterization of the orientation dependent material properties of FFF structures

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Motivation

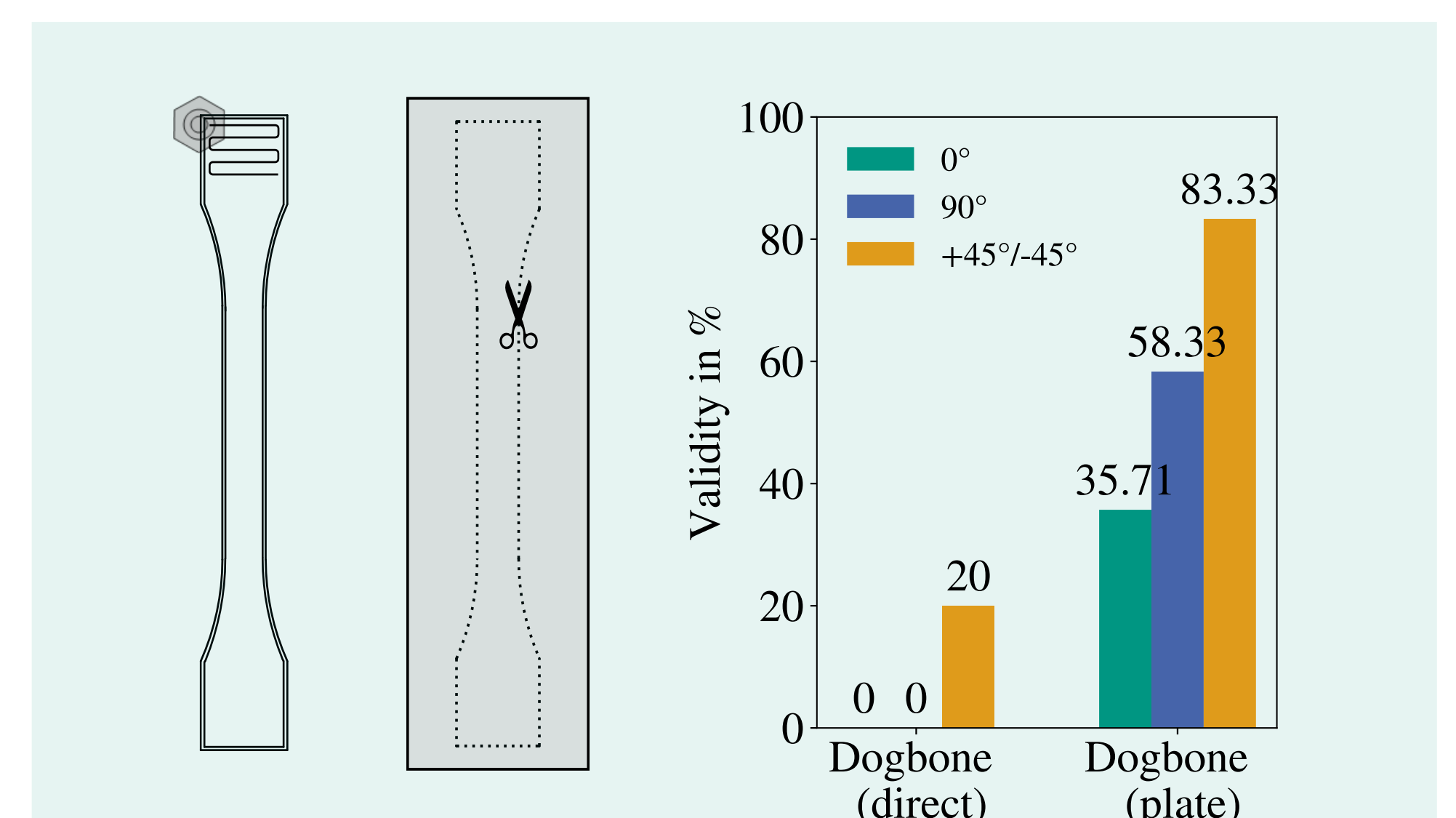
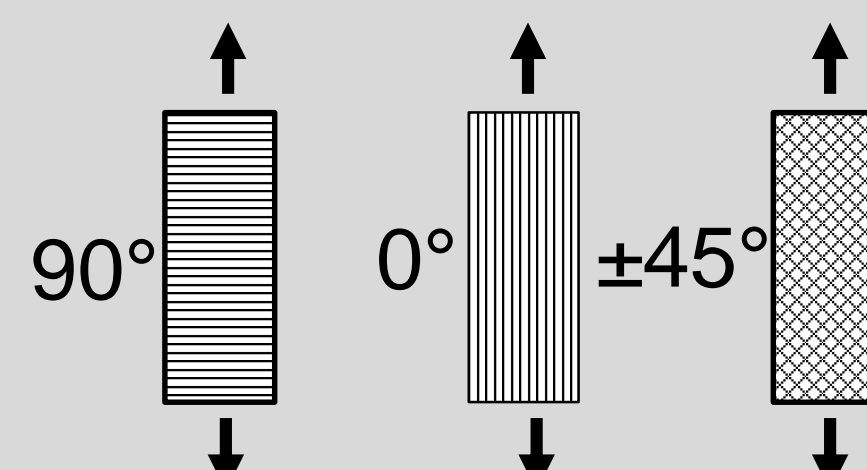
- There are several approaches for the preparation of specimens for the mechanical characterization of additively manufactured structures. [1-3]
- Due to inconsistent specimen preparation, the measured properties are difficult to compare.
- Studies are required to prepare the specimen that is representative of the structure to be tested.

Formulated requirements for a representative test specimen

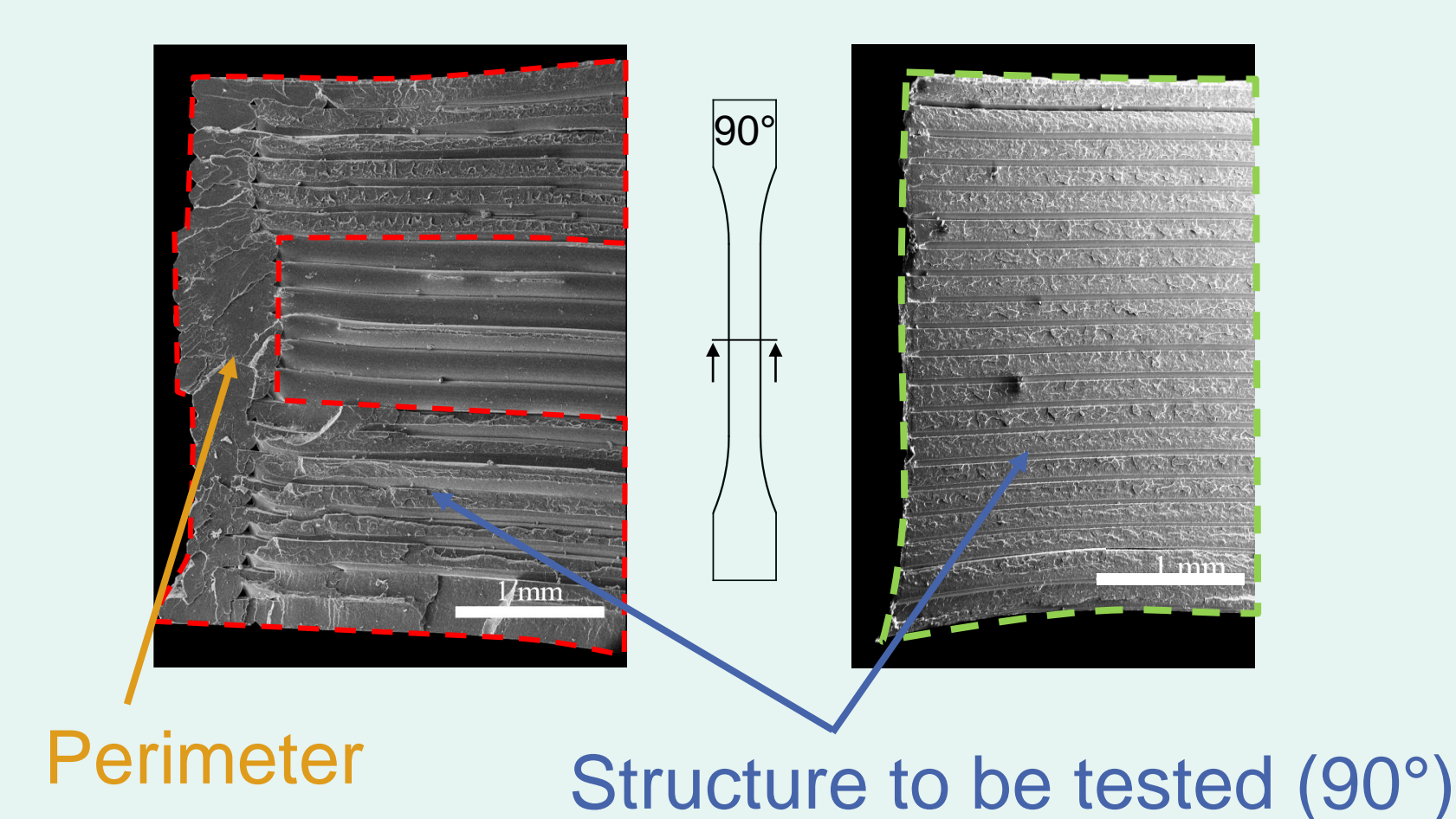
- The process-induced material orientation must be represented according to the structure under investigation.
- Process speed and the associated time interval between two deposited strands should be constant.
- To ensure a representative specimen, the scattering of experimental results should be minimized.
- Influences by possible preparation procedures should be minimized as far as possible.

Material and Method

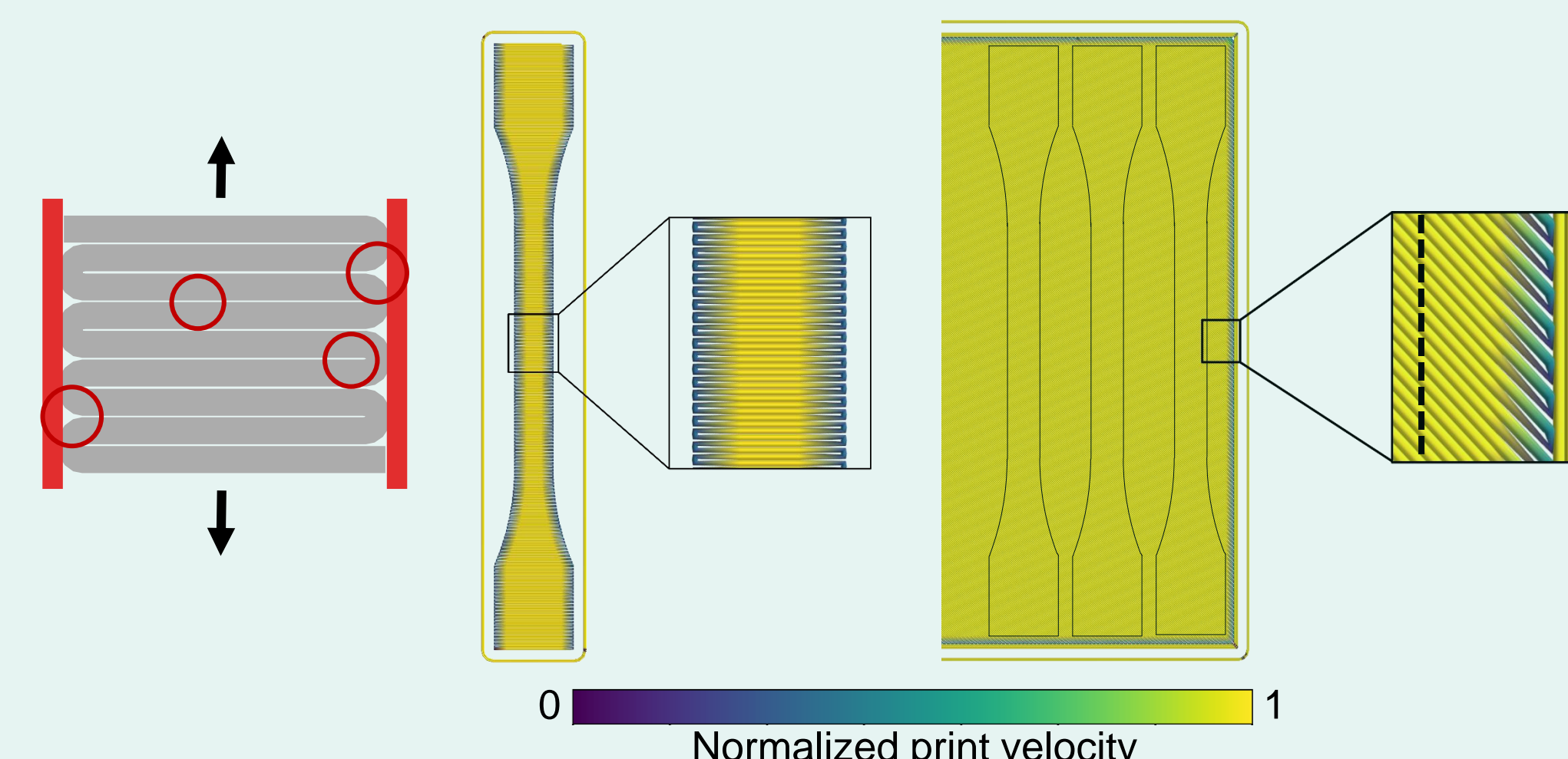
- Material: BASF Ultrafuse PLA filament
- Specimen 1B according to DIN EN ISO 527-2 with 100% infill and different strand orientation
- Printer: Ultimaker 2+
- Cutting method: waterjet cutting
- Tensile test with integrated GOM system for DIC measurements



Directly printed vs. cut



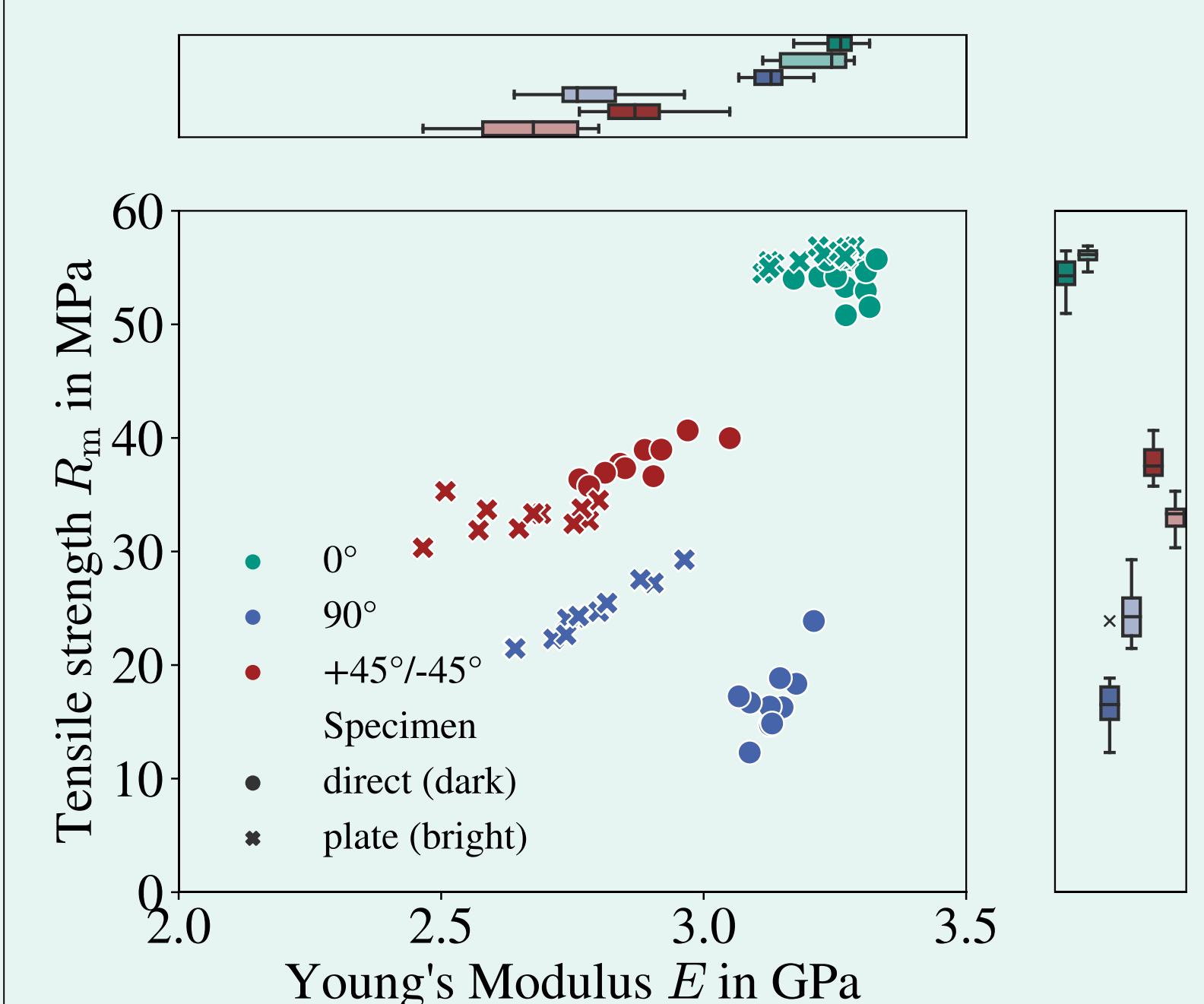
- The perimeter leads to non-uniform loading.
- Cut specimens allow the investigation of the structure under test.
- Cut specimens allow the study of local effects when loading specific infill structures.



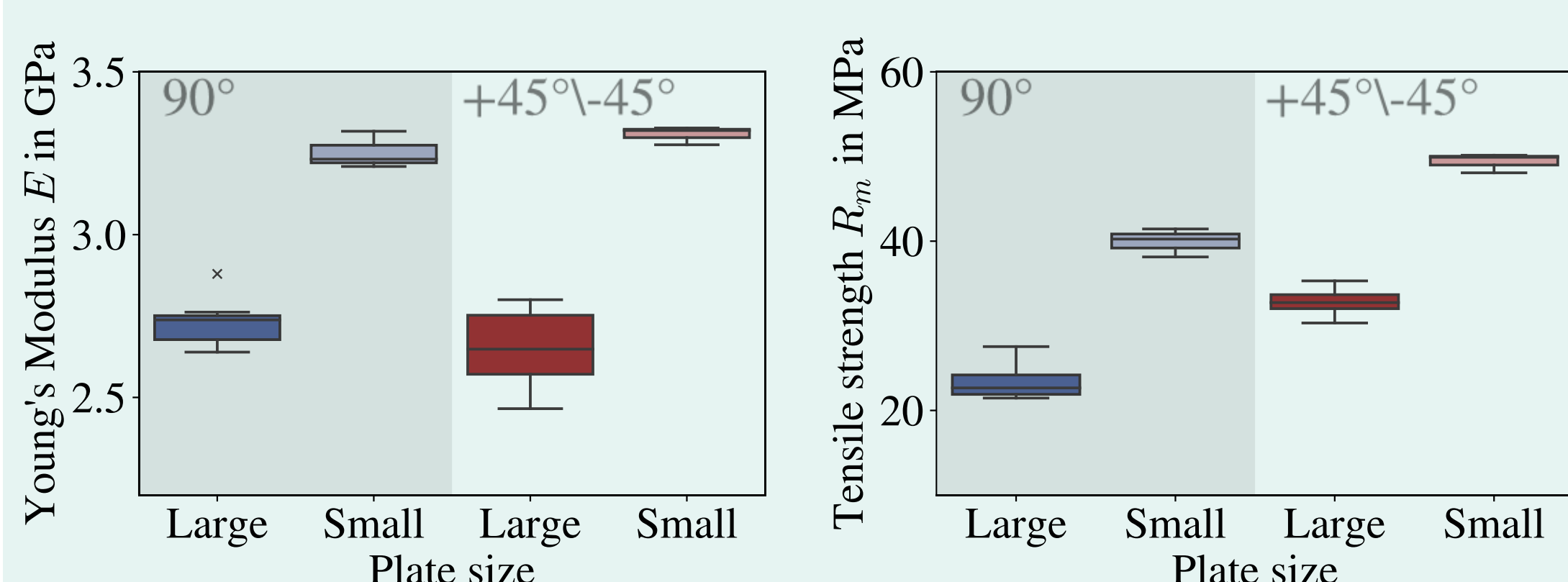
Directly printed specimens:

- Notch effect at the edge of the specimens.
- No constant printing speed.
- Varying degree of interfacial strength.
- Unidirectional section in cross section.

→ All tests were evaluated



Large plate vs. Small plate → Only valid tests were evaluated



- Smaller plate leads to less scattering.
- Smaller plate leads to higher mechanical properties.
- Due to shorter cooling time between two adjacent strands.

Conclusion

- Cut specimens allow experimental investigation of the structure under test within a component.
- Smaller plates result in a smaller scatter of the measured parameters.
- With this method, reproducible results can be obtained while maintaining process and preparation parameters.

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- [1] Gonabadi H, Yadav A, Bull SJ. The effect of processing parameters on the mechanical characteristics of PLA produced by a 3D FFF printer. International Journal of Advanced Manufacturing Technology 2020;111:695–709.
- [2] Ramirez MA, Barocio E, Tsai JT, Pipes RB. Temperature-Dependent Mechanical Properties of Additive Manufactured Carbon Fiber Reinforced Polyethersulfone. Applied Composite Materials 2022;29:2293–319.
- [3] Zhang Y, Choi JP, Moon SK. Effect of geometry on the mechanical response of additively manufactured polymer. Polymer Testing 2021;100.