FDM 3D-Printing in High-Pressure Oxygen and Pure Nitrogen Atmospheres & Evaluation of Mechanical Properties

by

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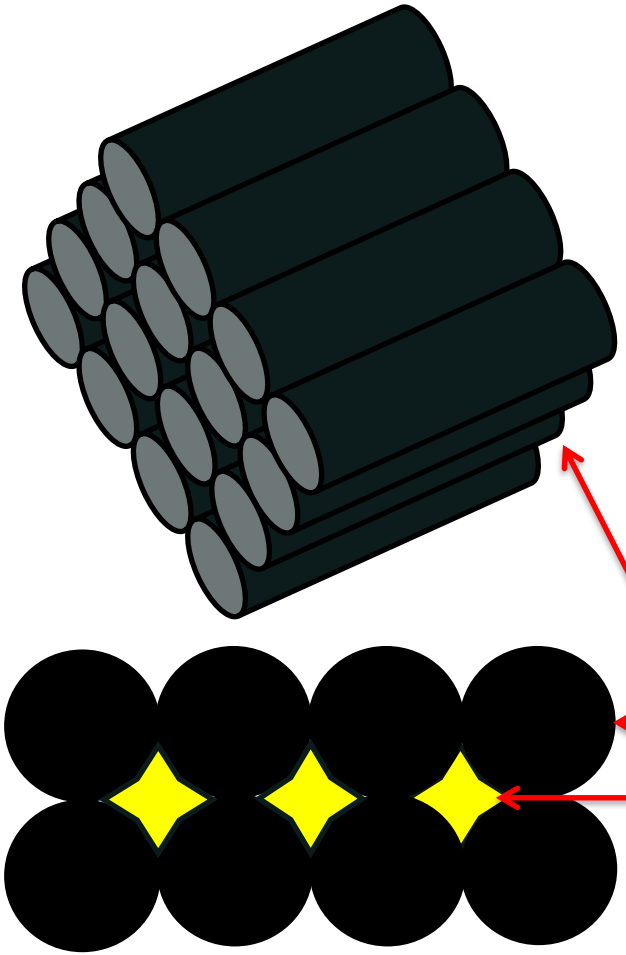
Objective



Problems - FDM

1) Voids
2) Oxidation of layers
3) Weak bonding
4) Warping

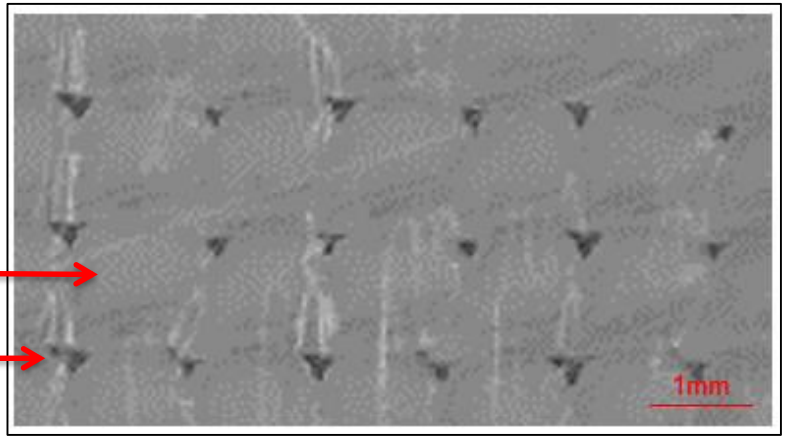


Fig. 1 SEM image of the 3D Printed sample

Approach - 3D Printer situated in the Autoclave

Autoclave ; 135 bar & 180 ˚C temperature can be maintanied

Cooling coils

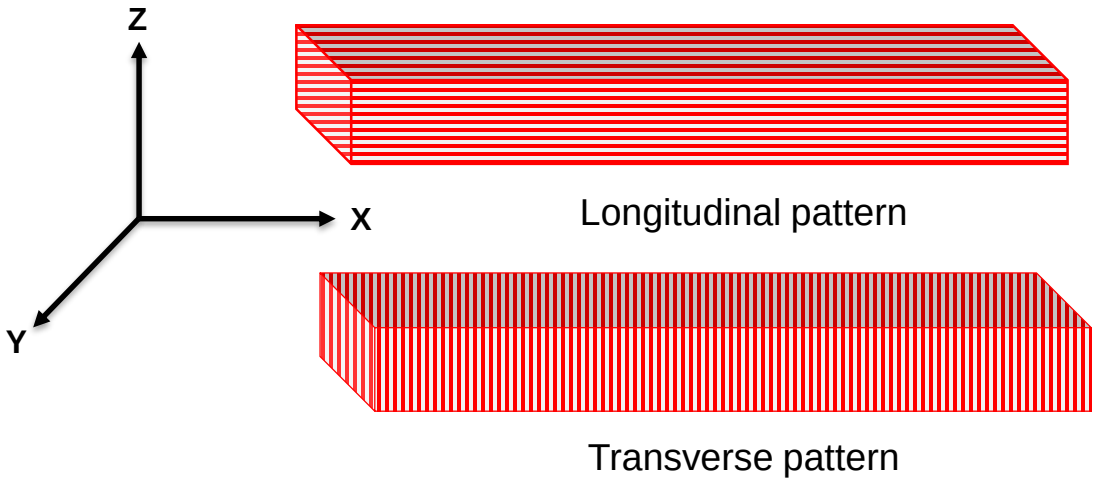
FDM-printer [Ender 3 V2] with PLA - spool

All cables (app. 60) are guided outside of the autoclave through special connectors.

Fig. 2 3D Printer in the autoclave

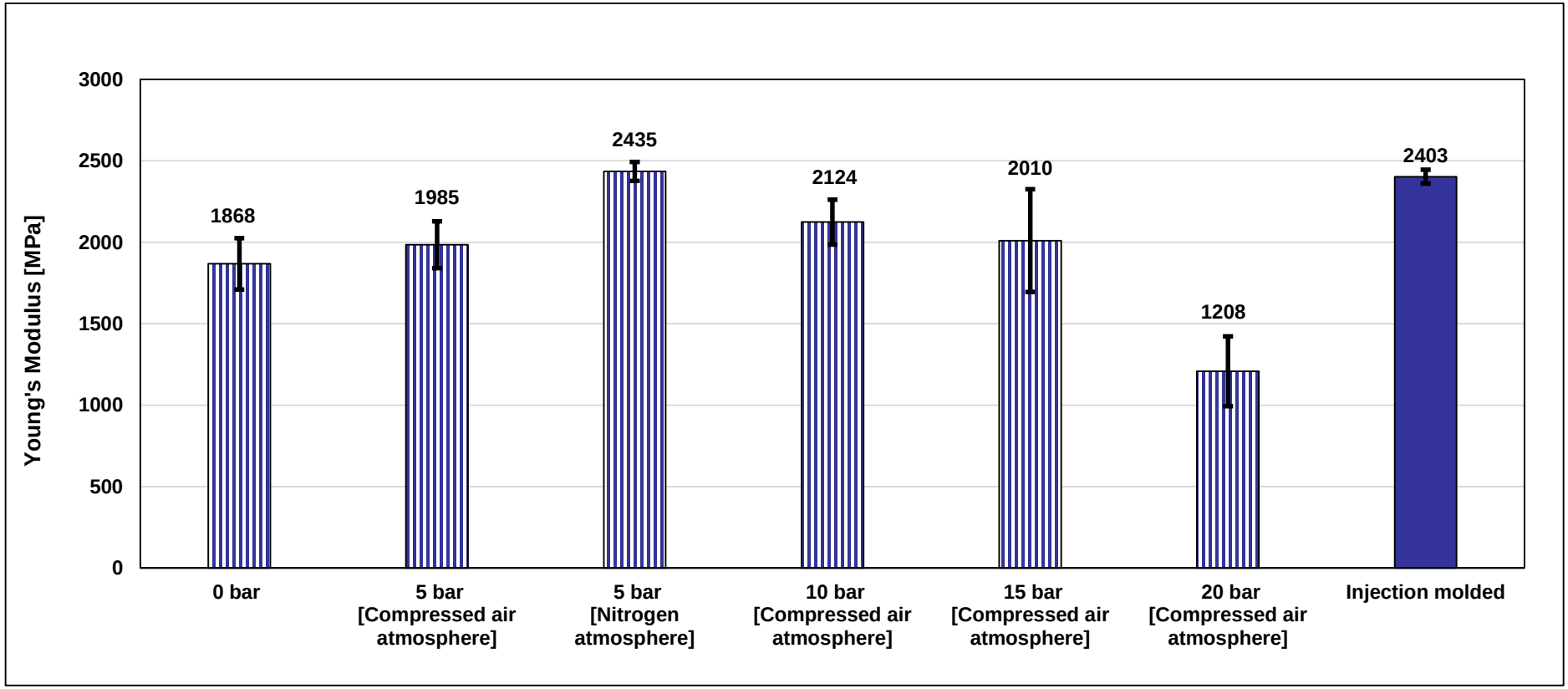
Experimental plan - 3D Printing in the Autoclave

- 3D printing in an autoclave at 0 bar, 5 bar, 10 bar, 15 bar, 20 bar in compressed air, and 5 bar in a Nitrogen atmosphere
- Material: PLA [Herz GmbH] – Granules & Filament
- Autoclave temperature = 50˚C
- Nozzle diameter = 0.5 mm
- Printing speed = 100%
- Layer thickness = 0.15 mm
- Hot end temperature = 200˚C
- Bed temperature = 60˚C



Modulus - longitudinal pattern

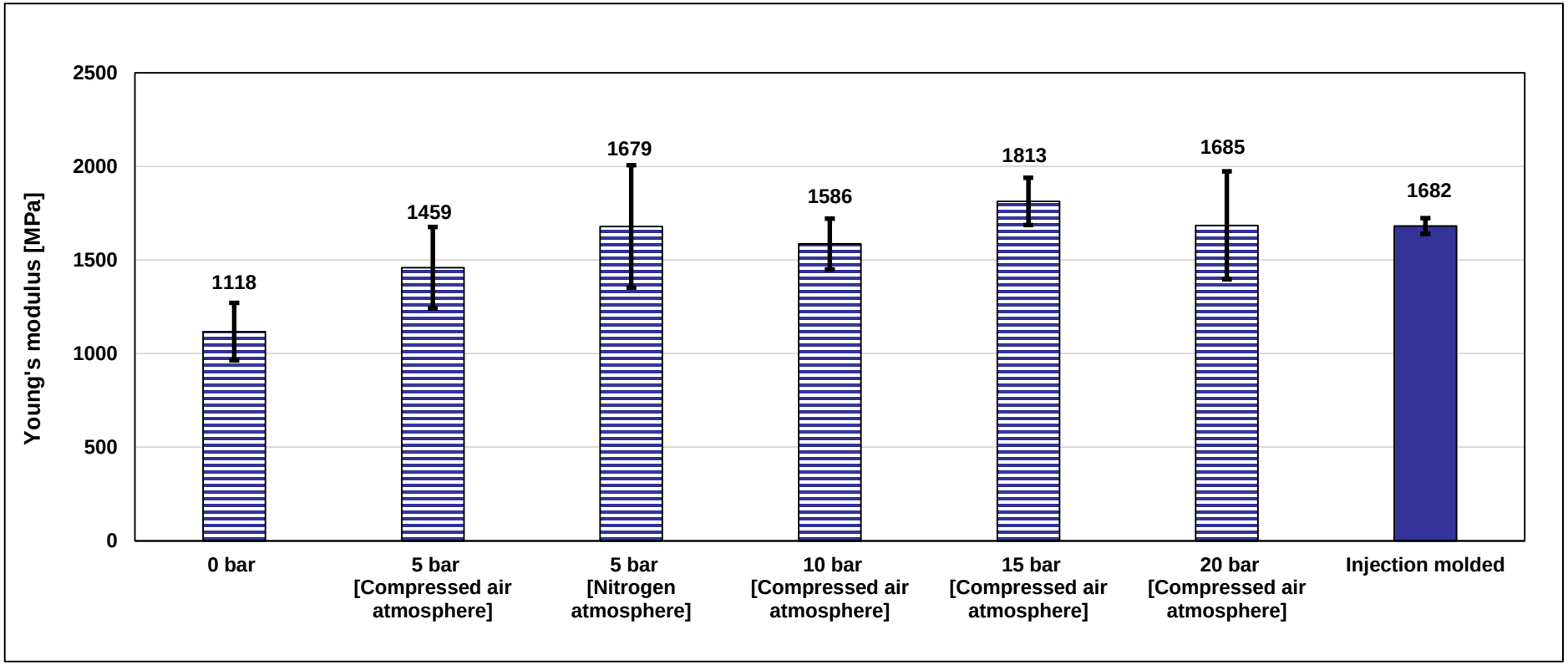
- Young´s modulus comparison of samples printed in the longitudinal direction in different pressure conditions with injection molded samples



Test standard: DIN EN ISO 527-1

Modulus - transverse pattern

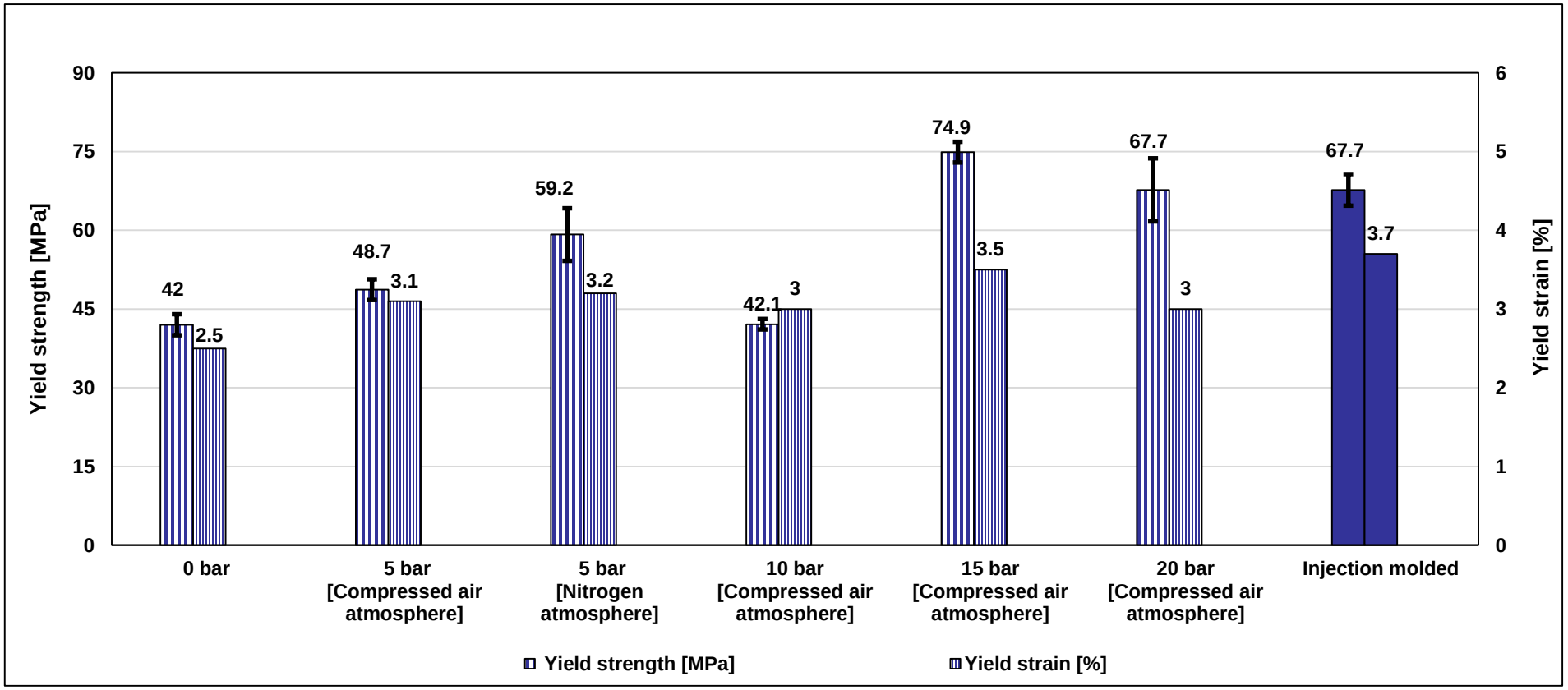
- Young´s modulus comparison of samples printed in the transverse direction in different pressure conditions with injection molded samples



Test standard: DIN EN ISO 527-1

Yield strength - longitudinal pattern

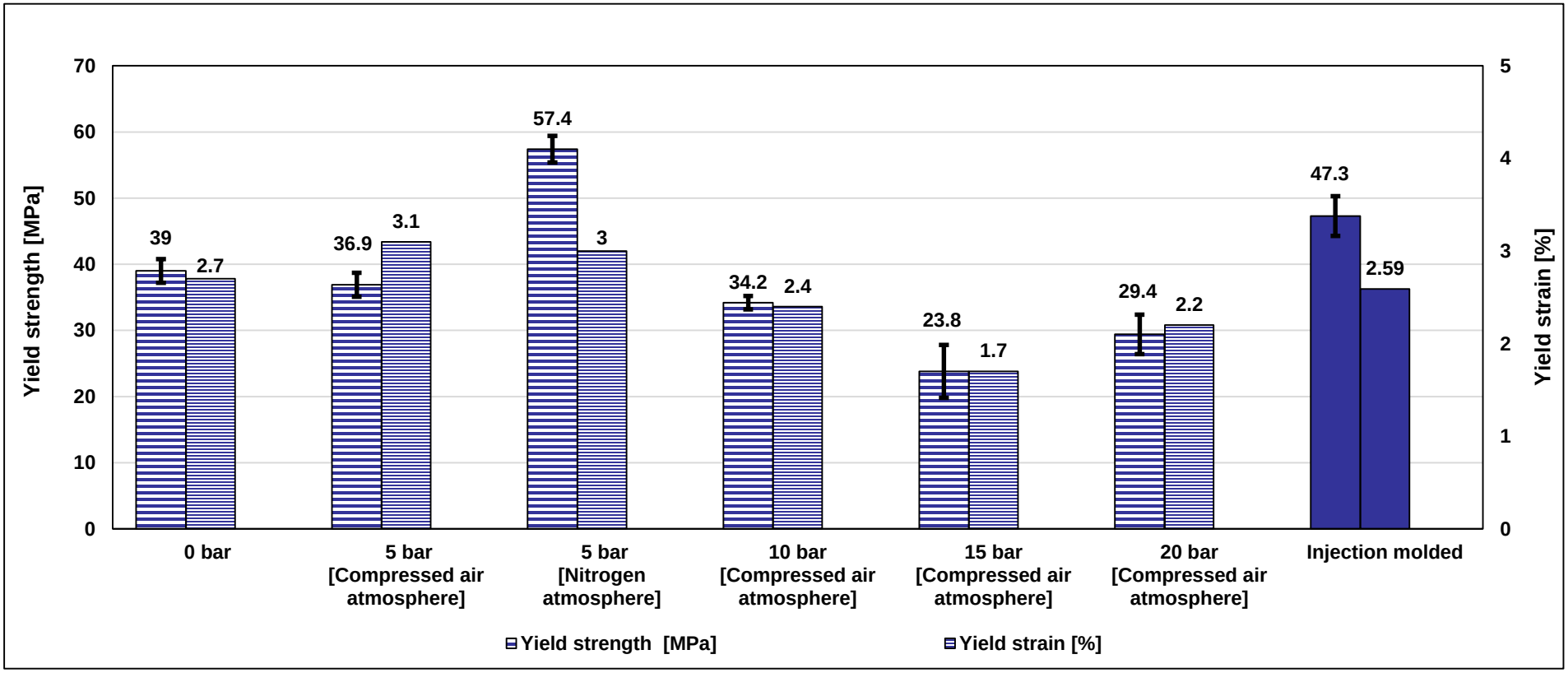
- Yield strength comparison of samples printed in the longitudinal direction in different pressure conditions with injection molded samples



Test standard: DIN EN ISO 527-1

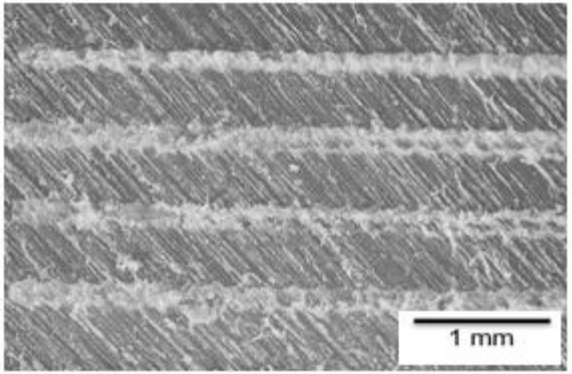
Yield strength - transverse pattern

- Yield strength comparison of samples printed in the transverse direction in different pressure conditions with injection molded samples

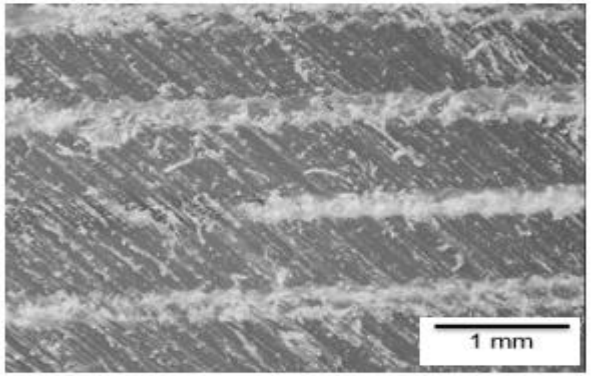


Test standard: DIN EN ISO 527-1

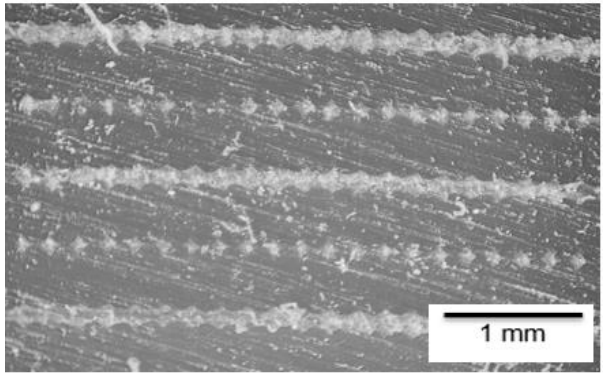
Microscopy test results



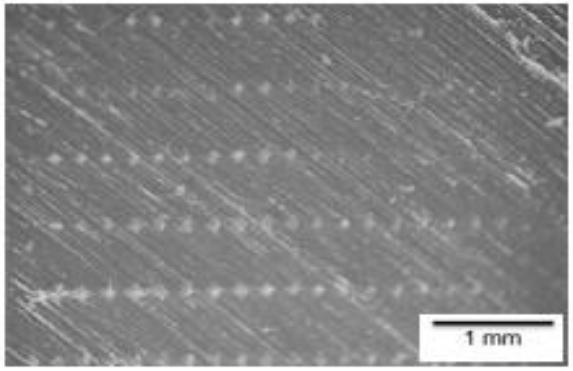
At 0 bar



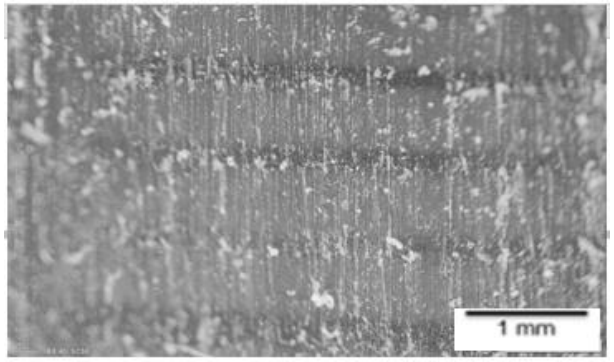
At 5 bar



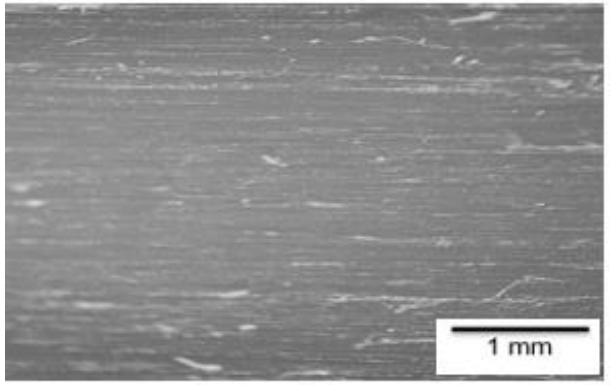
At 10 bar



At 15 bar



At 20 bar



Injection molded

Conclusion

- Mechanical strength increased
- Reduce voids
- Better layer adhesion
- Material density increment
- Surface finish

Thank You for Listening

Any Questions?