Mechanical Properties of Polypropylene from 3D Printing

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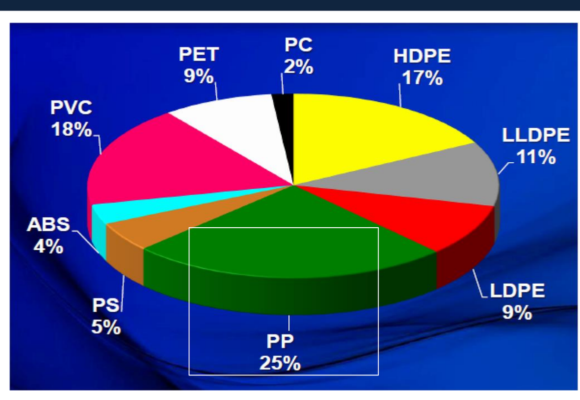
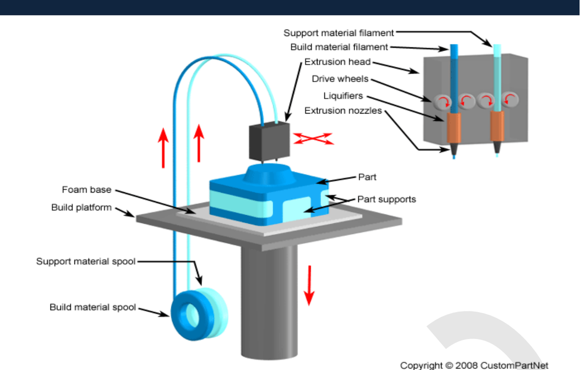
Introduction

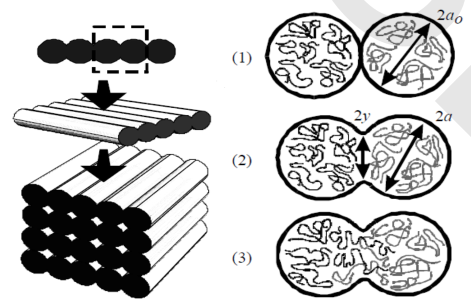


Market share of PP



FDM device configuration

PP shrinks and warps during FDM

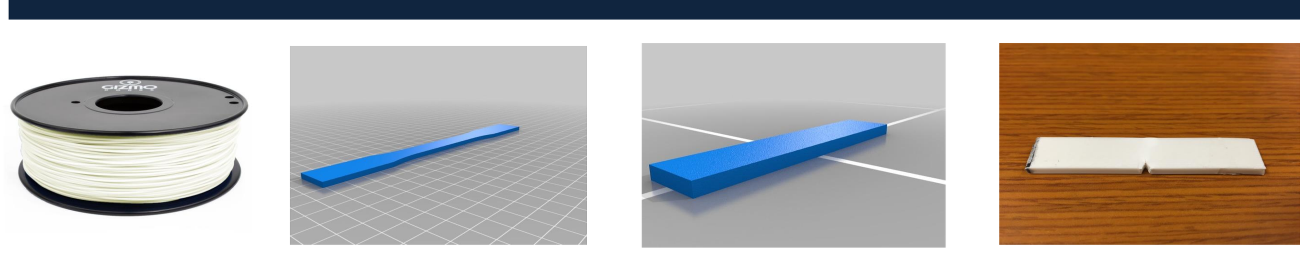


Molecular diffusion at interfaces

Objective

1. To learn how FDM processing parameters influence the mechanical properties of PP.
2. To anticipate how cellulose nanofibrils (CNFs) could improve the mechanical properties of printed PP.

Materials and methods



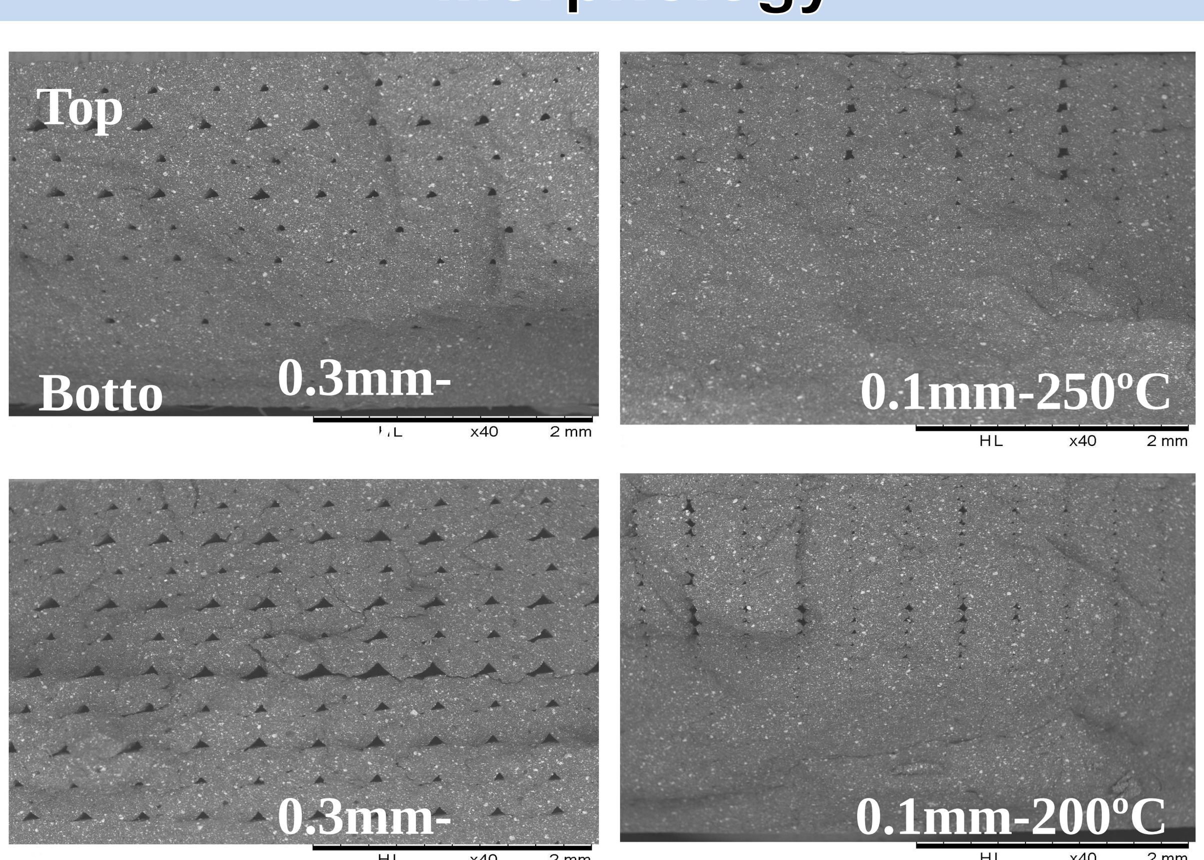
Shapes of mechanical test specimens

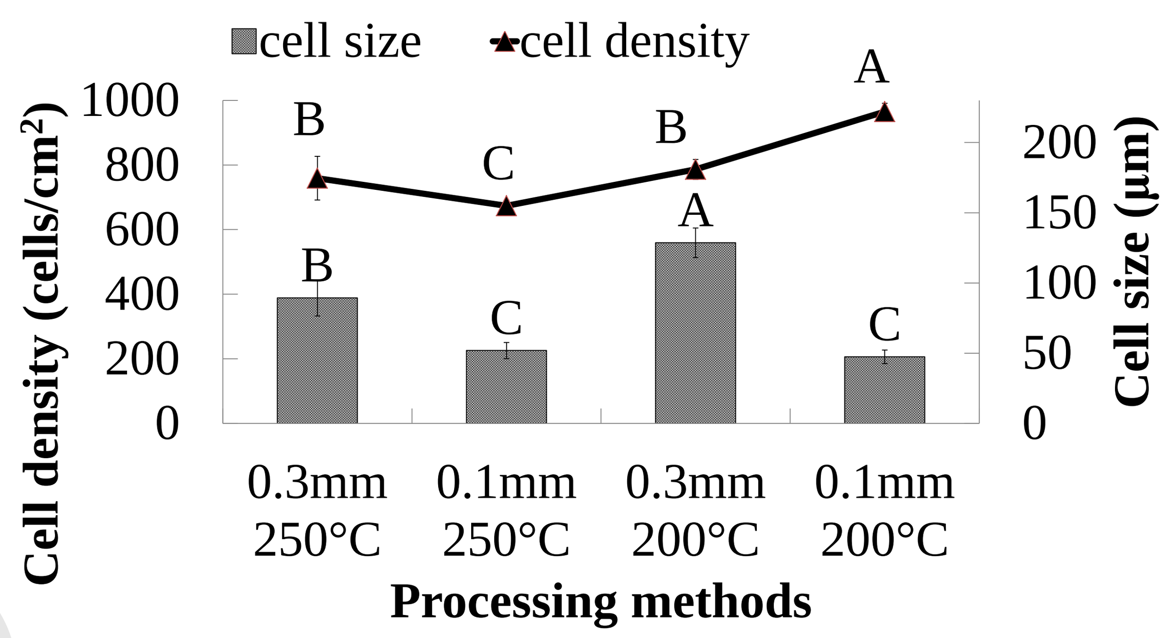
Table 1. Experimental design

Method	Layer height/mm	extrusion temperature/ºC
FDM	0.3	250
	0.1	250
	0.3	200
	0.1	200

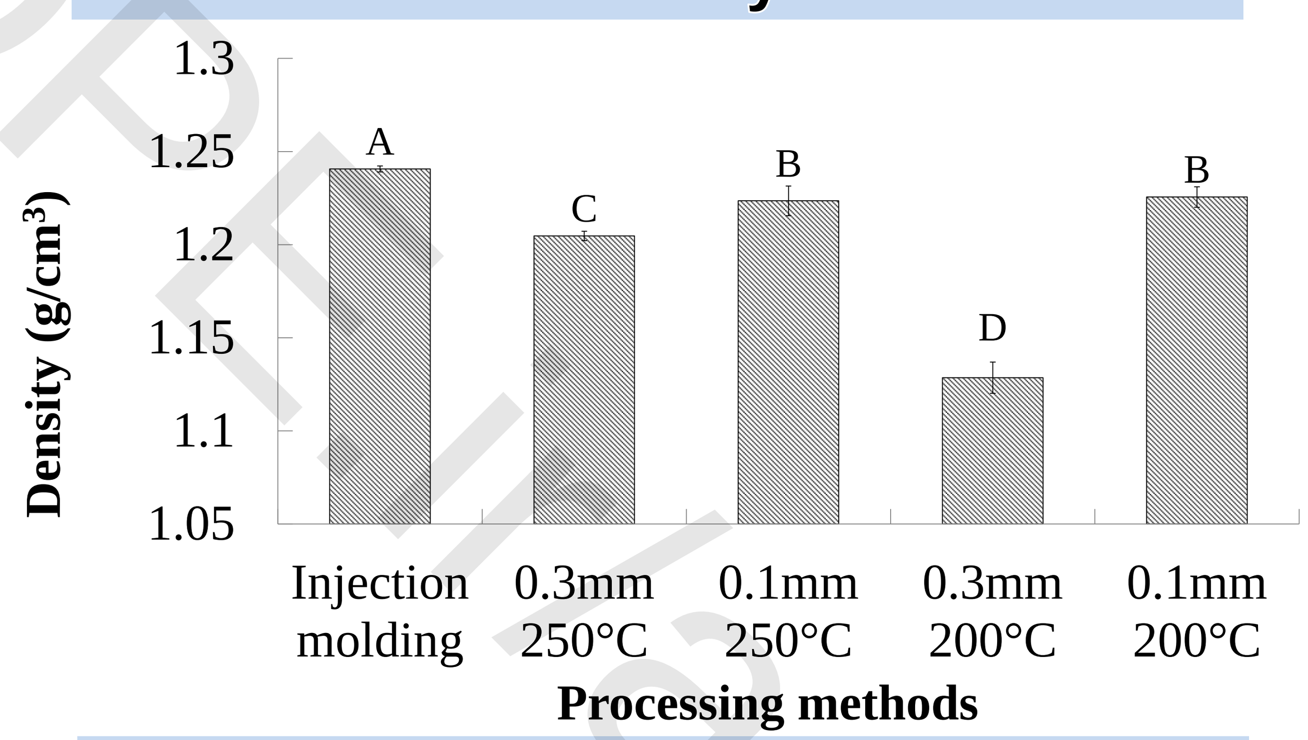
Results and Discussion

Morphology

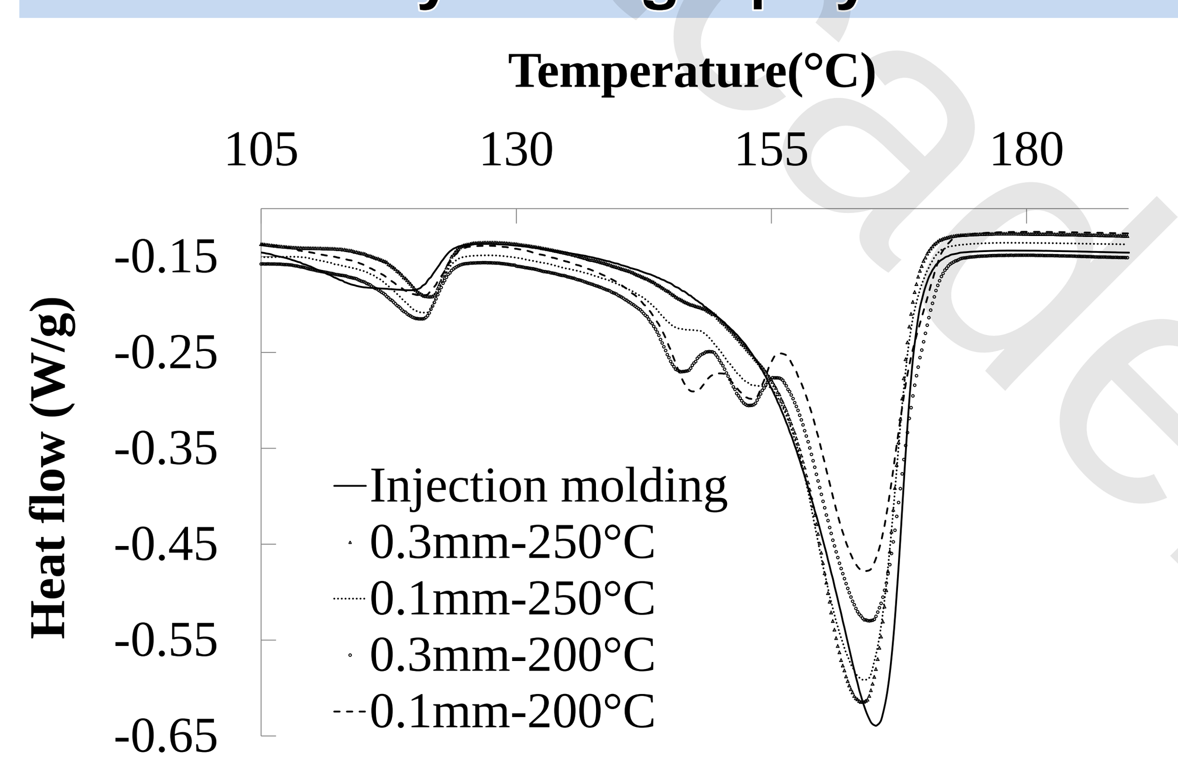




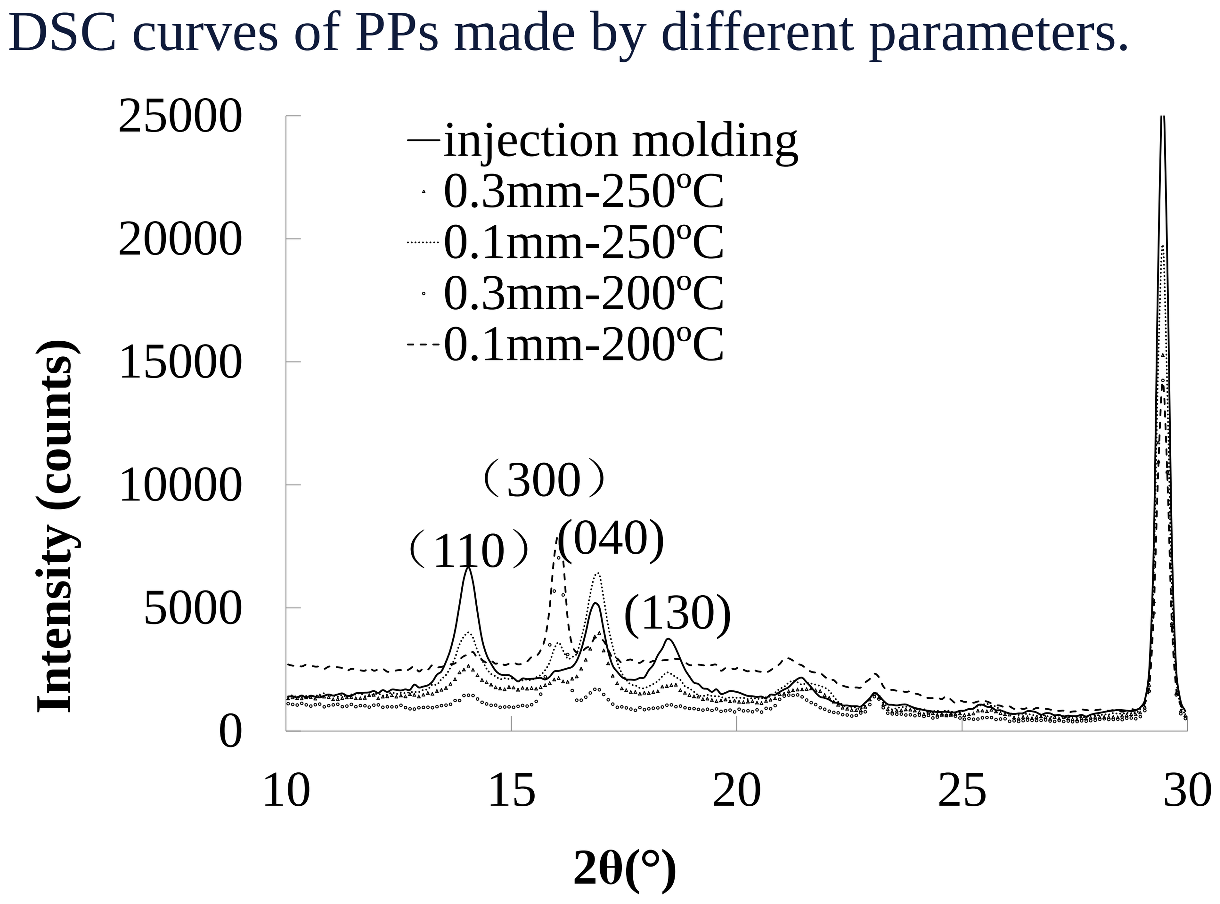
Density



Crystallography



DSC curves of PPs made by different parameters.

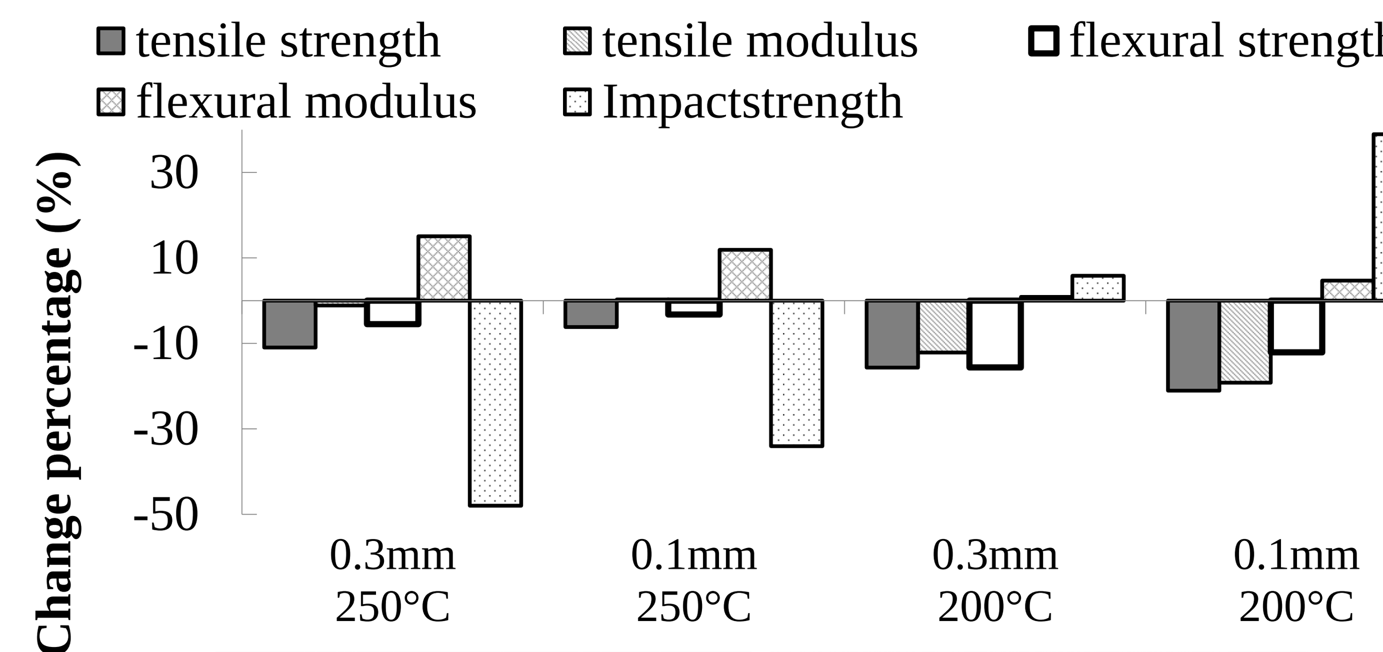


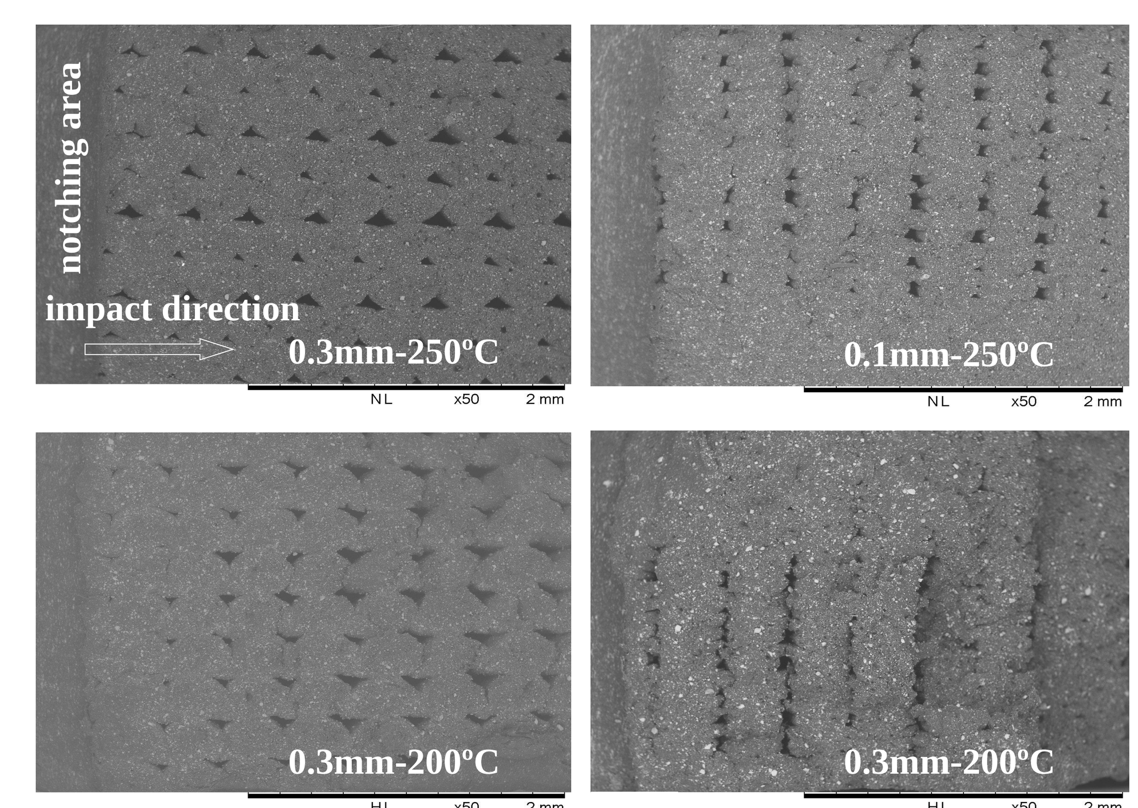
XRD curves of PPs made by different parameters.

Table 2. β-crystal content in various printed PPs

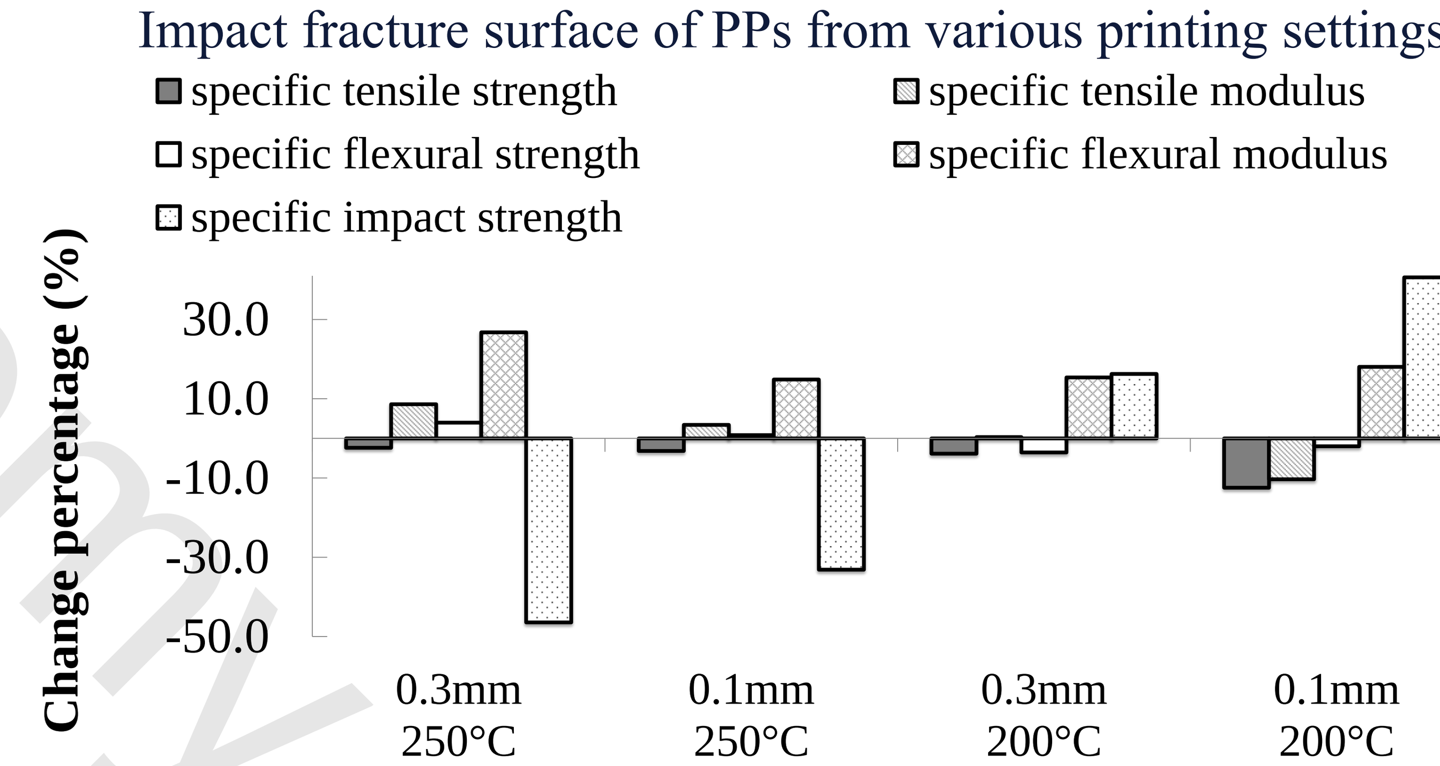
Injection molding	0.3mm 250ºC	0.1mm 250ºC	0.3mm 200ºC	0.1mm 200ºC
4.6	5.6	11.4	75.1	75.2

Mechanical properties





Impact fracture surface of PPs from various printing settings



Conclusions

- ❑ Smaller layer height and higher extrusion temperature led to smaller cell size but larger cell density.
- ❑ Printed PP was lighter than injection molded PP. Smaller layer height resulted in denser parts.
- ❑ Both α and β type crystals exist in printed PP where the β content was much more predominant in PP printed at 200 ºC.
- ❑ Compared to the injection molded PP, tensile and flexural strength decreased less for the PP printed at 0.1 mm and 250 ºC , while the flexural modulus remained and impact strength decreased most.
- ❑ More interface breaks and plastic deformation were found in PP printed at lower temperature and smaller layer height.
- ❑ CNFs have the potential to at least enhance the modulus without compromising the impact strength of injection molded PP.

Acknowledgements

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