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Continuous Fibre Lattice Fabrication: Free Form Printing of Fibre Composite Structures

Additive manufacturing (AM), also known as 3D printing, is an emerging and potentially revolutionary technology aimed at small volume manufacturing for highly customized applications, e.g. aerospace, medical devices, and replacement parts. However, the processing technology still requires a lot of development before it can be used to manufacture final parts beyond mere prototypes. The AM of continuous fibre reinforced thermoplastic composites, in particular, presents its own set of challenges compared to processes that work with neat polymers, metals, and ceramics due to the anisotropy of the material.

Continuous Fibre Lattice Fabrication (CFLF), a patented technology developed at the ETH Zurich, is the first to present a truly 3D fabrication processes not based on layer by layer build ups, capable of fabricating out-of-plane reinforcements. The free forming technique does not depend on supporting structures to provide shape and therefore enables the fabrication of free standing structures like lattices. CFLF requires no moulds or additional equipment and imparts form to the structure by constructing the fibre tows along desired load paths in 3D space. Conventional technologies constrain design freedoms and consequently limit the possibility to fully exploit the potential of Fibre Reinforced Polymeric Composites (FRPC). Thus, the ability to free form structures represents a significant advancement in the processing of composite materials.

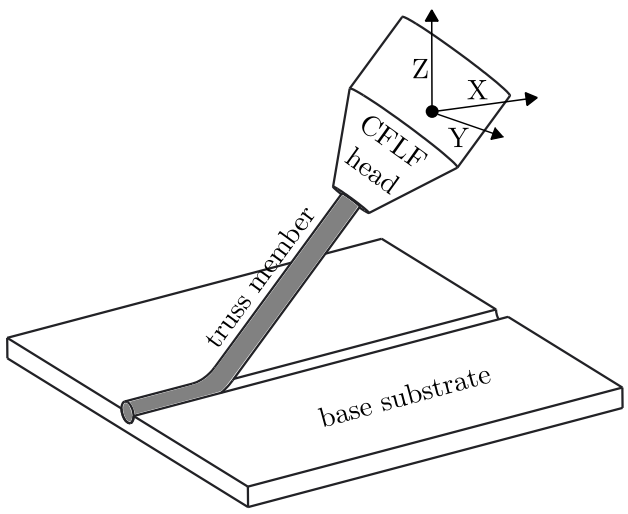
Martin Eichenhofer
ETH Zurich
martieic@ethz.ch (correspondence)

Dr. Joanna Chi-Hing Wong
ETH Zurich
wongj@ethz.ch

Prof. Dr. Paolo Ermanni
ETH Zurich
permanni@ethz.ch

Additive Manufacturing + Continuous Fibre Reinforcements

The addition of reinforcement fibres to polymer melts results in significant advancements in mechanical performance. However, the continuity of the fibres is essential for high performance applications, hence a directed deposition along contours is required. CFLF (Continuous Fibre Lattice Fabrication) was developed at ETH Zurich to provide true free form capability by a directed spatial deposition along desired trajectories in all spatial coordinates .



Case Study

	Conventional AM (PLA)	CFRP AM
Strength:	52 MPa	560MPa
	+ 1100%	
Stiffness:	3 GPa	83 GPa
	+ 2600%	
Costs:	30-50 €/kg	55 €/kg
	+ 10%	

*data CMASLab, ETH Zurich

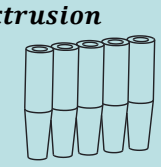
Potential of Technology

$cost < 60\ ^{€}/_{kg}\ (carbon)$
$cost < 50\ ^{€}/_{kg}\ (glass)$

$speed > 1000\ ^{cm^3}/_{h}$
$void\ cotent < 3\ \%$

$strength > 600\ MPa$
$stiffness > 80\ GPa$

multiple extrusion nozzles



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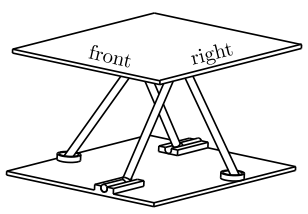
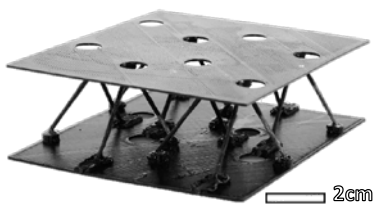
Recent Developments and Ongoing Research

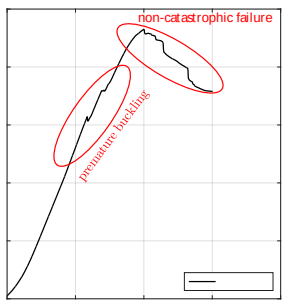
The latest focus in CFLF processing were set on the development of a new prototyping machine, lightweight test specimen as well as the processing characterization in terms of processing conditions and their interdependencies. The general goal of the project is to increase the production speed, achieve void contents below 3%, development of simulation tools to anticipate material behaviour and showcase the potential by manufacturing of a demonstrator structure.

New CFLF prototyping machine





CFLF printed test specimen



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