

# MORPHO workshop: Advances in Laser Shock Techniques and Carbon Fiber Recovery for Composite Materials

*European Recycling and Circularity in Large Composite Components (EureComp):  
Sizing Effect on Reclaimed Continuous Carbon Fibres' Properties Extracted from Recycled  
Automotive Composite Parts*

*Dionisis Semitekolos*

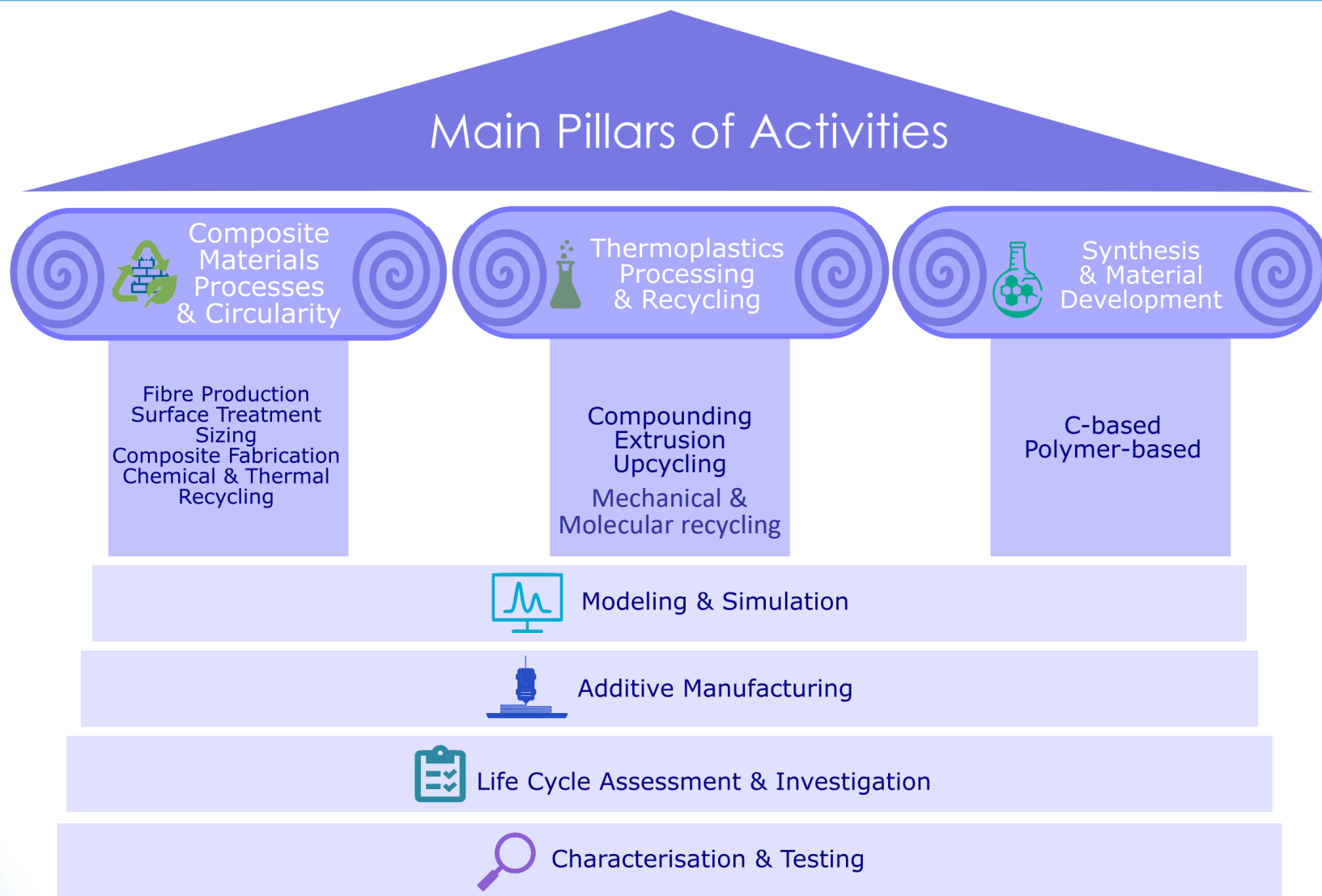
**Director: Prof. Costas A. Chatididis**

*<https://r-nano.gr>*



**schoolofchemicalengineering**  
nationaltechnicaluniversityofathens

# Main Pillars of Activity



# CFs Production



## Continuous Carbonization plot line for CFs production



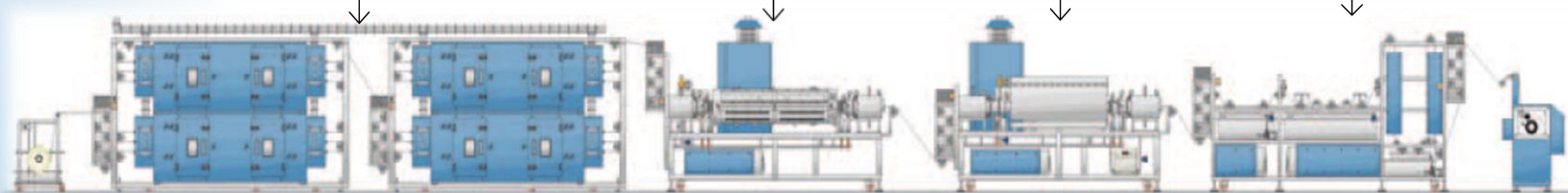
Stabilization  
(180-350°C)

LT Carbonization  
(800-1200°C)

HT Carbonization  
(1200-2000°C)

Surface  
treatment

Production speed:  
0.3m /min (4m/h)  
Inert atmosphere  
(Nitrogen/Argon)



LOW

Energy consumption

HIGH

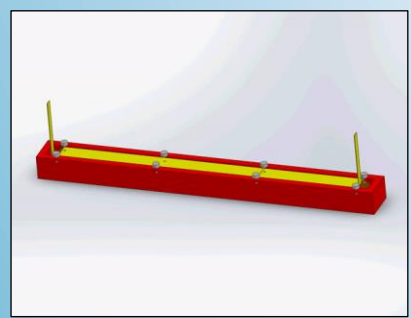
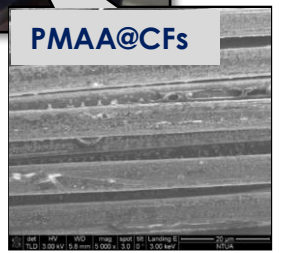
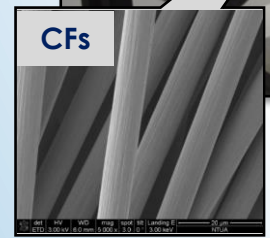
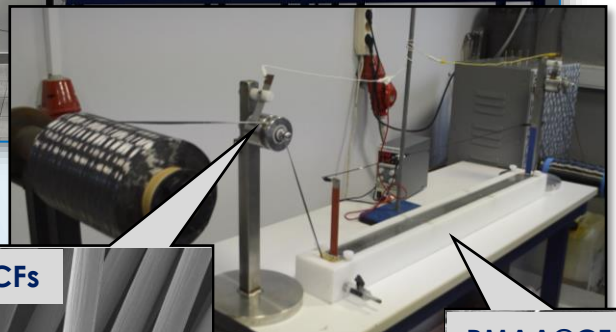
 SUSPENS

  
www.FibralSpec.net

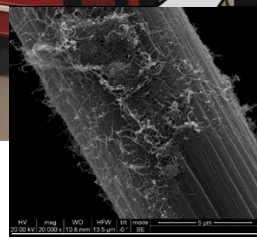
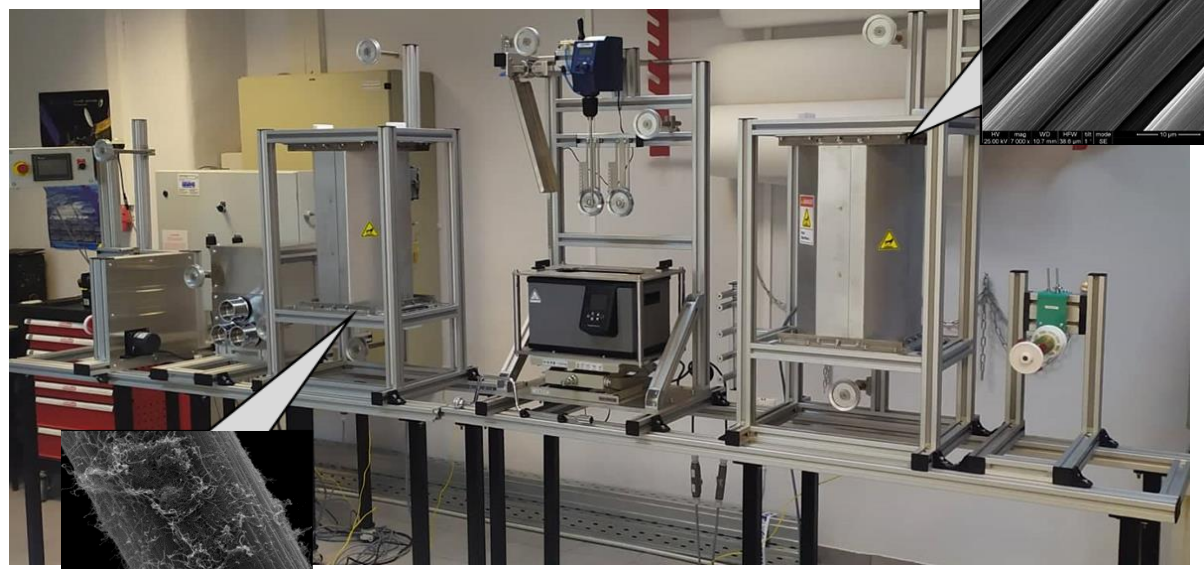
# Continuous line for surface treatment



## Surface treatment on CFs via electropolymerisation of MAA



## Pilot Scale Sizing line



# Circularity of Composites



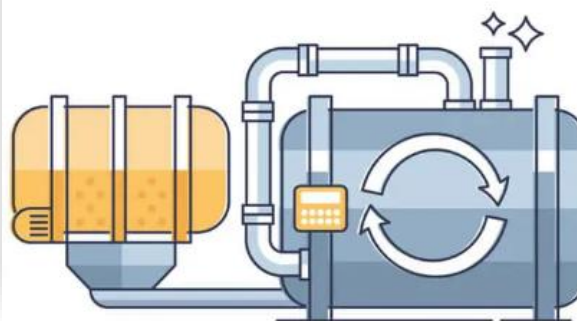
## 10L Pilot scale Low Temperature Reactor



## 4L Pilot scale High Temperature High Pressure Reactor



## Pyrolysis Batch Process



## Reclamation of CFs & GFs

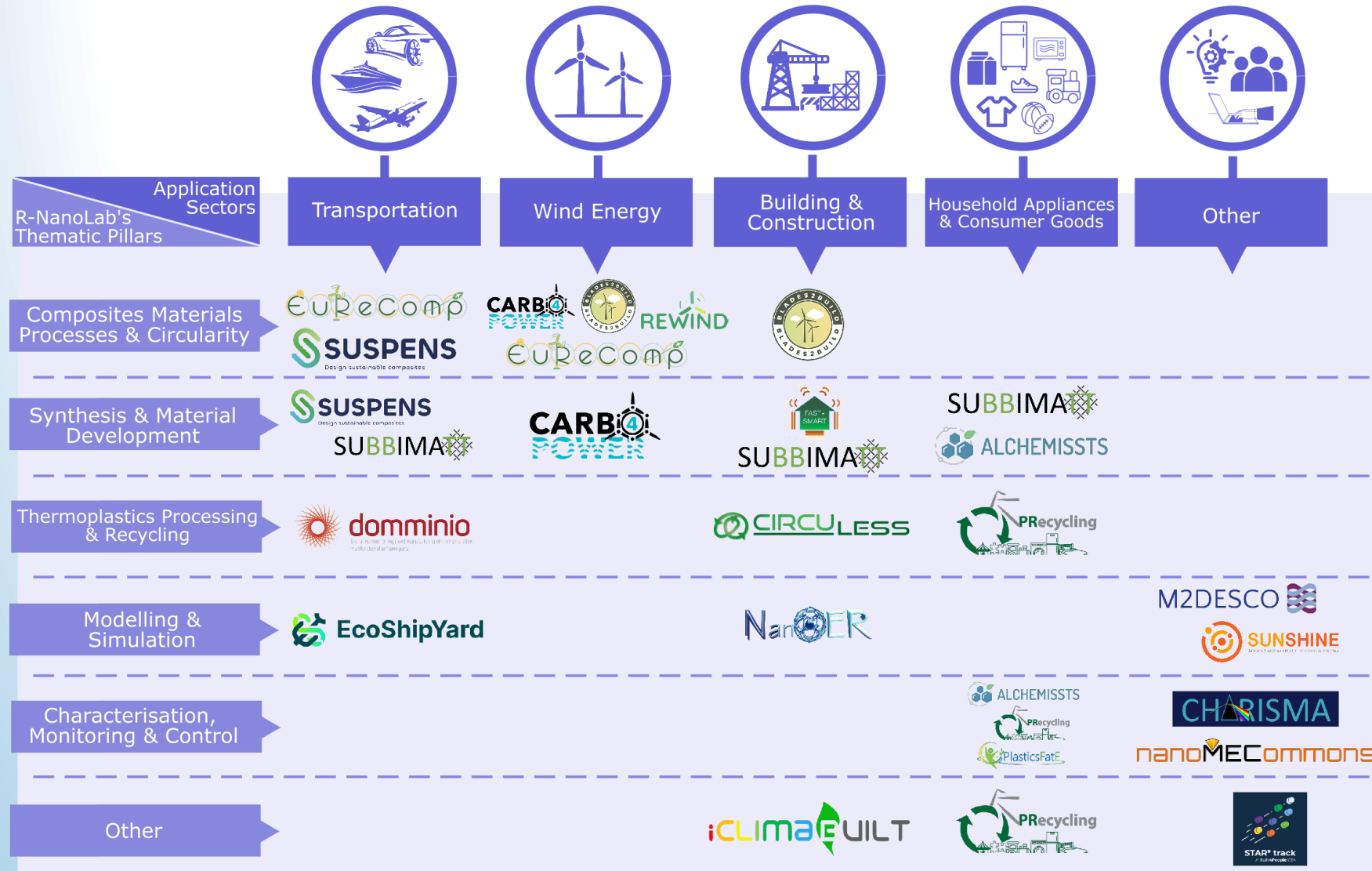


Tailored **recycling-by design** material features



**Design for Recycling (DfR)** approaches

# R-NanoLab Ongoing Projects



## *Upgrade and evaluation of chemically recycled CFs*

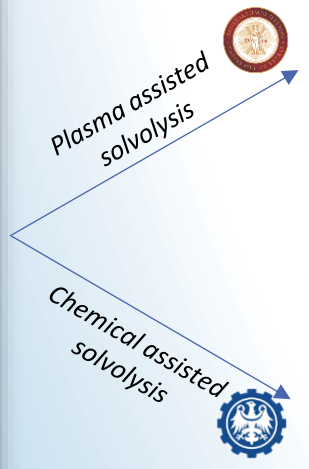
- *I. Recycling process*
- *II. Pilot scale sizing line*
- *III. Recycled fibre characteristics*
- *IV. Optical microscopy analysis & results processing*
- *V. Mechanical testing*



# Upgrade and evaluation of chemically recycled carbon fibres



Composite specimen  
manufactured with Filament  
Winding



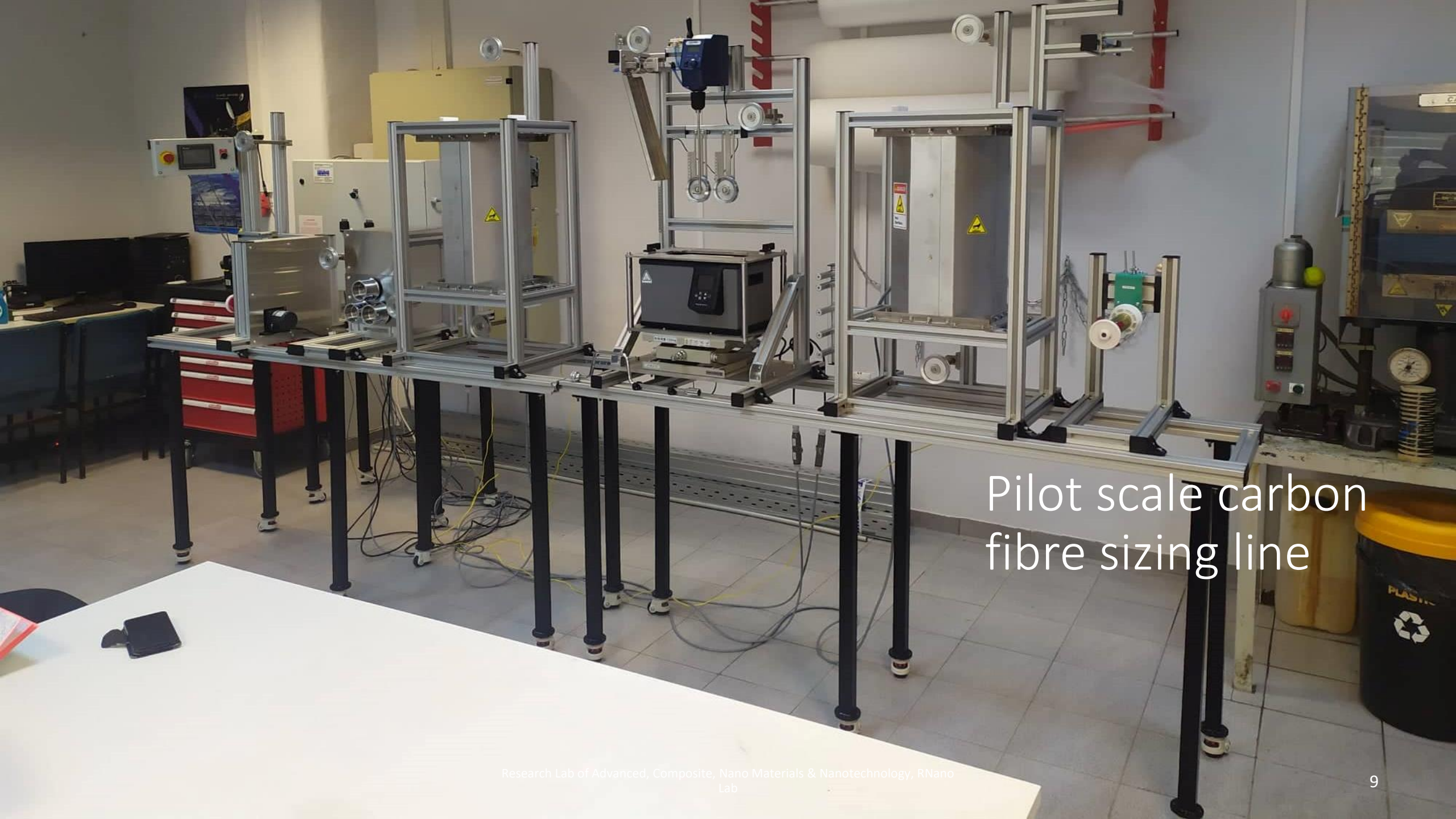
Continuous Carbon Fibre Reclamation

Plasma assisted solvolysis  
or Chemical assisted treatment

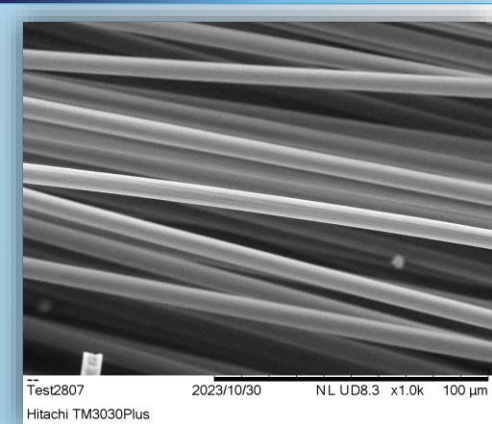


Continuous recycled Fibre  
winding

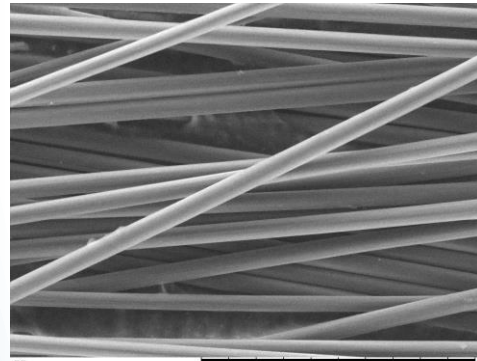




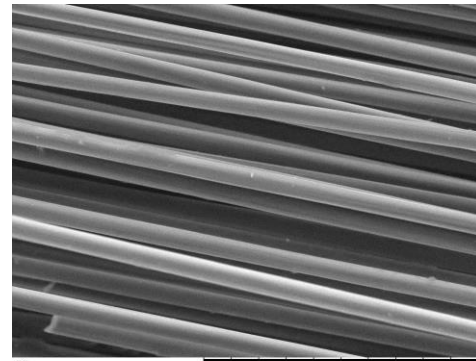
Pilot scale carbon fibre sizing line



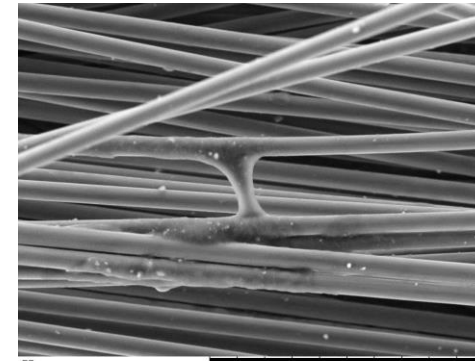
Reference Fibre x1000



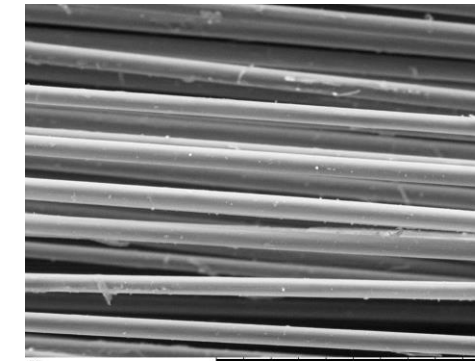
Plasma Recycled Fibre x1000



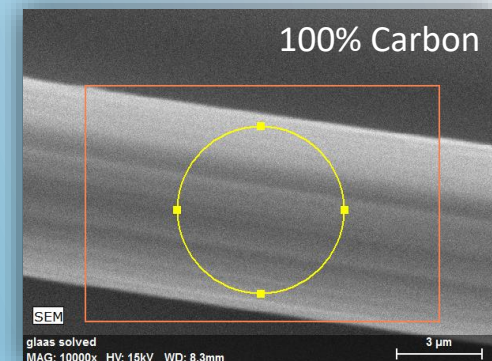
Plasma Recycled & Sized Fibre x1000



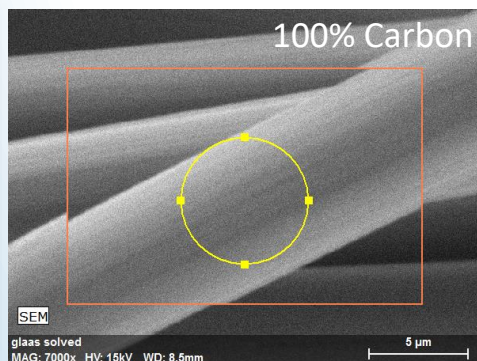
Chemically Recycled Fibre x1000



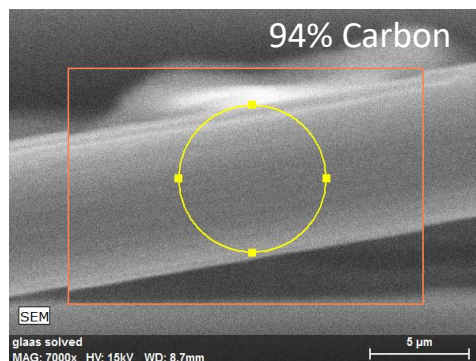
Chemically Recycled & Sized Fibre x1000



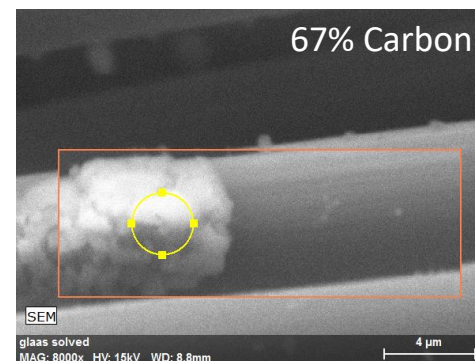
EDS analysis of reference fibre



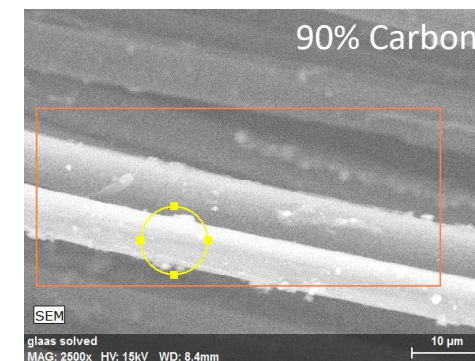
EDS analysis of plasma recycled fibre



EDS analysis of plasma recycled & sized fibre



EDS analysis of chemically recycled fibre



EDS analysis of chemically recycled & sized fibre

### Reference Results:

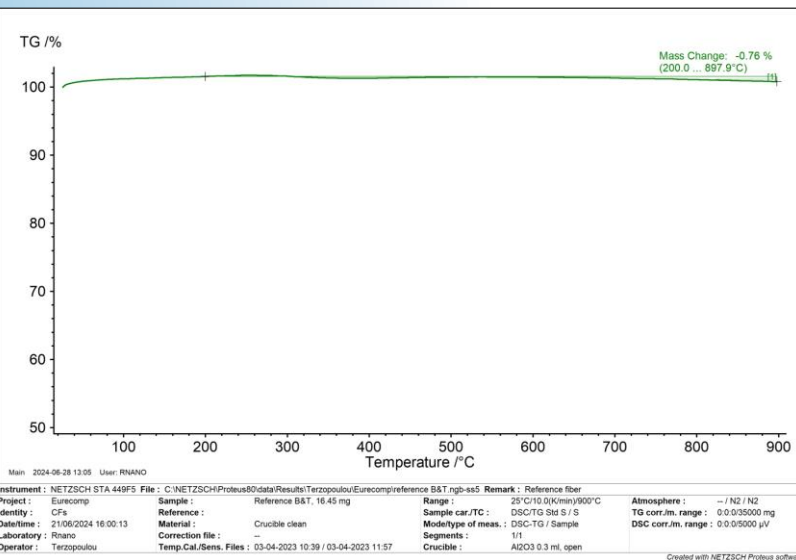
- Smooth rigged surface

### Plasma Results:

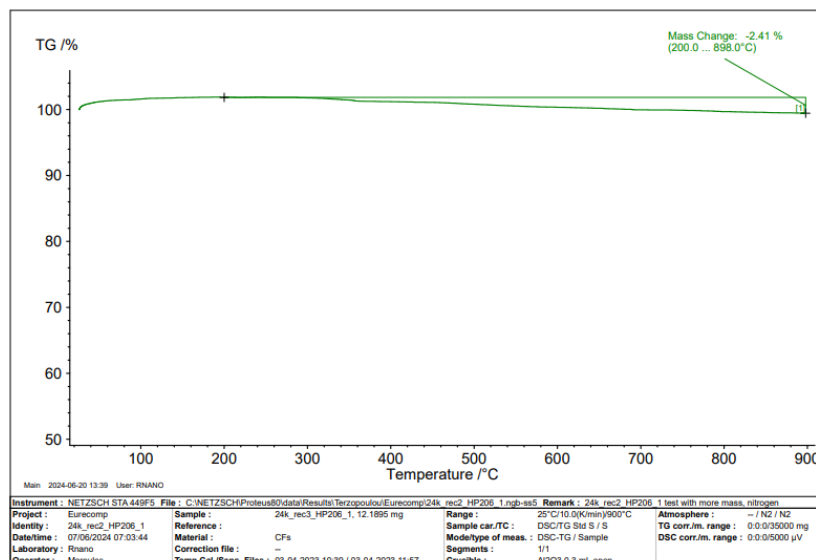
- No resin residues after recycling
- No visual filament damage
- Good surface morphology after sizing

### Chemically assisted Results:

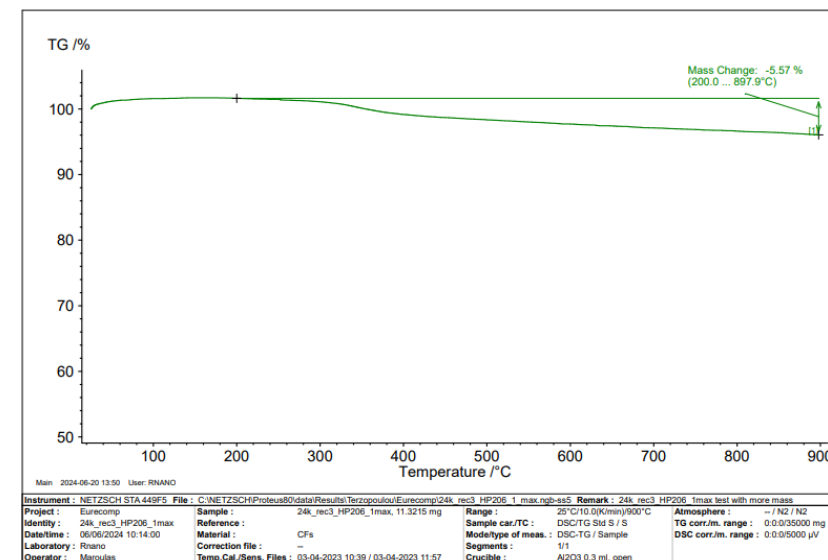
- Few resin residues after recycling
- No visual filament damage
- Few resin spots after sizing



Reference Fibre



Plasma Recycled & Sized Fibre



Chemically Recycled & Sized Fibre

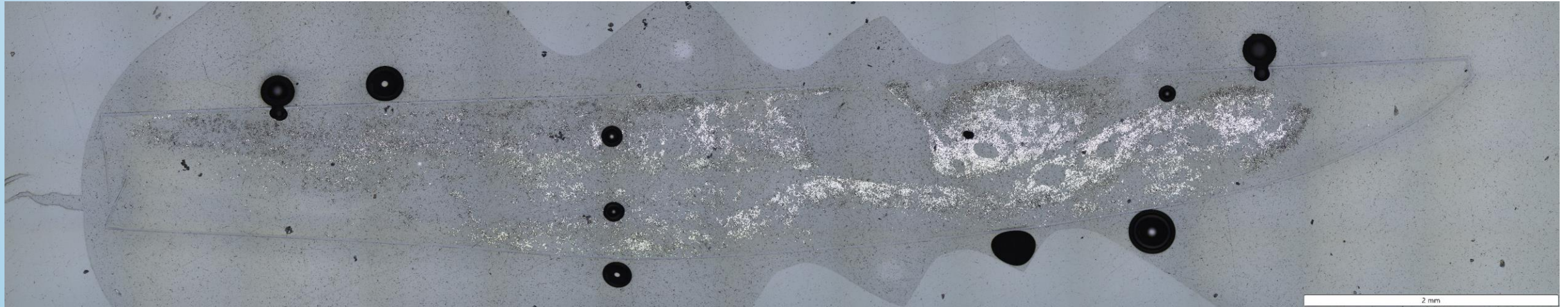
## TGA Results:

- CF maintain their structural integrity for both recycling cases
- There is ~3% resin residue on the CF from chemically recycling process

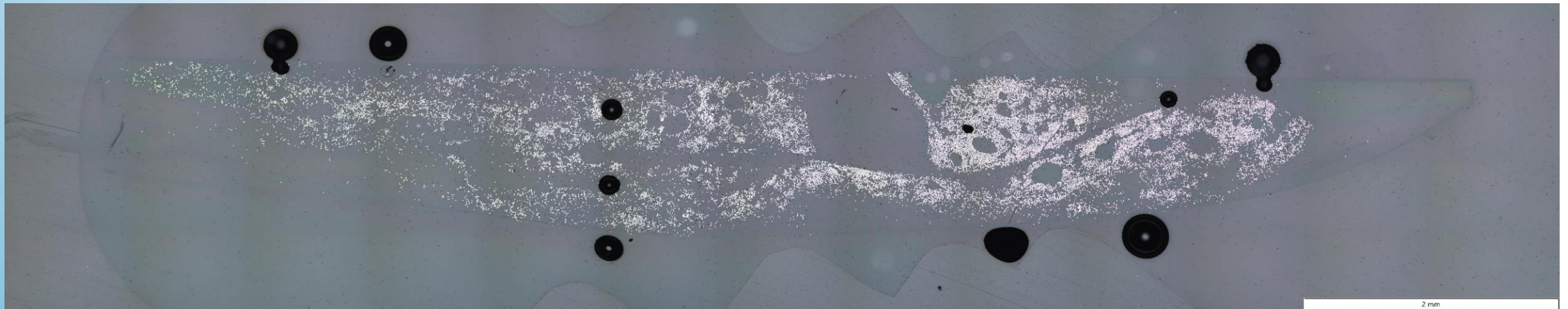
# Optical Microscopy Analysis



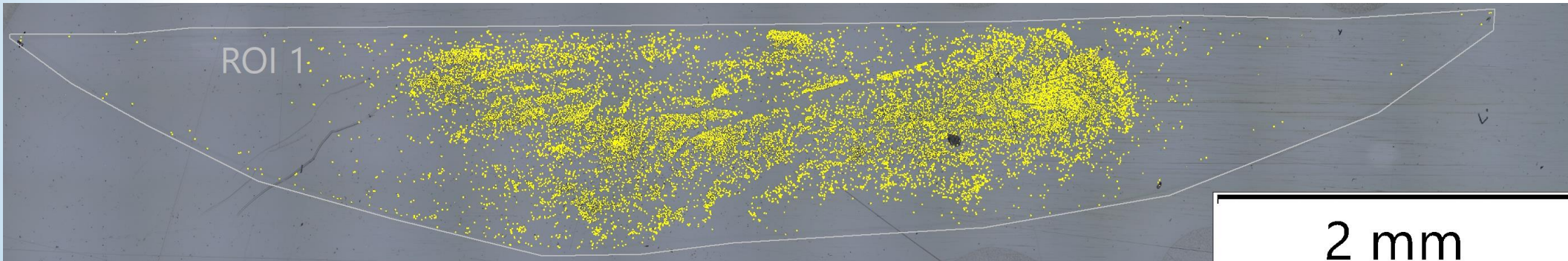
# Optical Microscopy Analysis



10min polishing

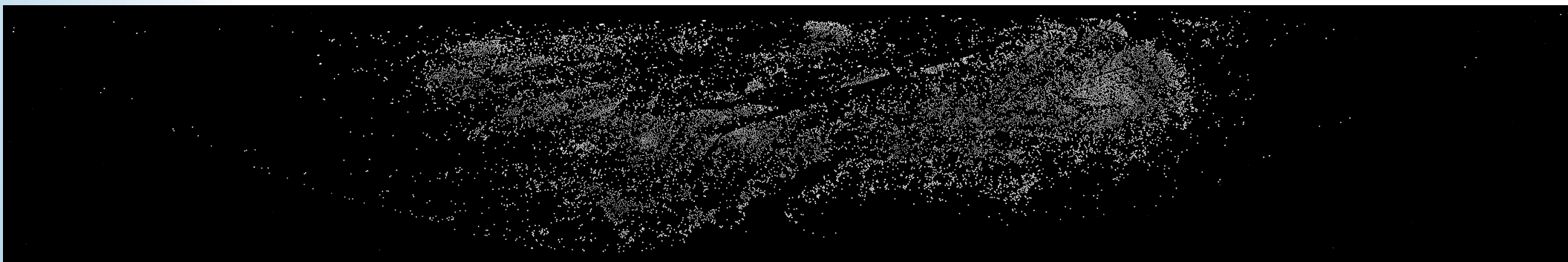


20min polishing



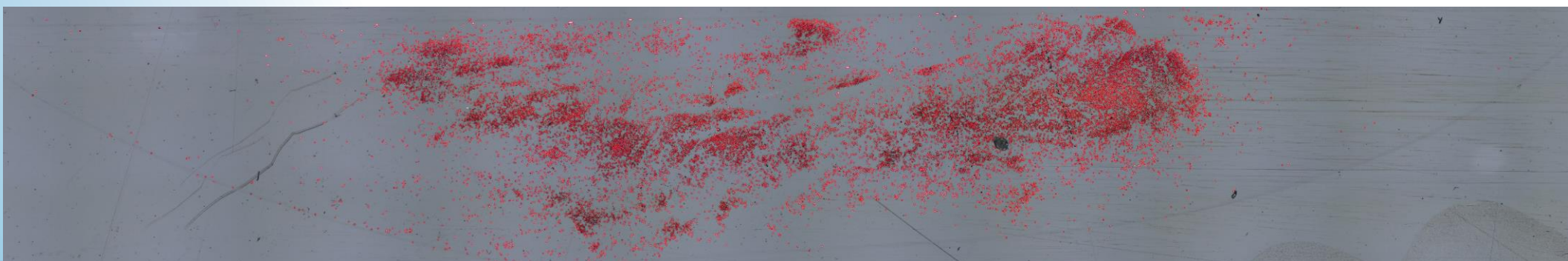
Filament count  
14856 ± 1294  
8.7%

Olympus  
software



Filament count  
23700 ± 1391  
5.9%

ImageJ



Filament count  
23725 ± 820  
3.5%

Python

# Tensile tests



## Results of tensile testing on CF bundles

<i>Specimen</i>	<i>Tensile strength (GPa)</i>	<i>% difference to Ref_CF</i>
Ref_CF	2.7 ± 0.3	N/A
Ch_rCF	2.2 ± 0.2	-18
Sized_Ch_rCF	2.4 ± 0.3	-11
Pl_rCF	2.1 ± 0.3	-22
Sized_Pl_rCF	2.4 ± 0.4	-11



## Results of tensile testing on single CFs

<i>Specimen</i>	<i>Tensile strength (GPa)</i>	<i>% difference to Ref_CF</i>
Ref_CF	3.60 ± 0.38	N/A
Ch_rCF	3.04 ± 0.48	-15.6
Sized_Ch_rCF	3.29 ± 0.21	-8.6
Pl_rCF	3.15 ± 0.38	-12.5
Sized_Pl_rCF	3.30 ± 0.28	-8.3

- Filament exhibits a 10% decrease in the sized recycled fibre
- Unsized fibre exhibits quite lower tensile strength (~22%), probably due to the non uniform shape of the rod



Thank you for your time



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