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Up-scaling of CNT-doped thermoplastic veils production

IMPROVEMENT OF CFRP ELECTRICAL CONDUCTIVITY

Anna Boczkowska

Paulina Latko-Duralek, Pawel Duralek, Michal Towpik, Przemyslaw Kosmider

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BACKGROUND

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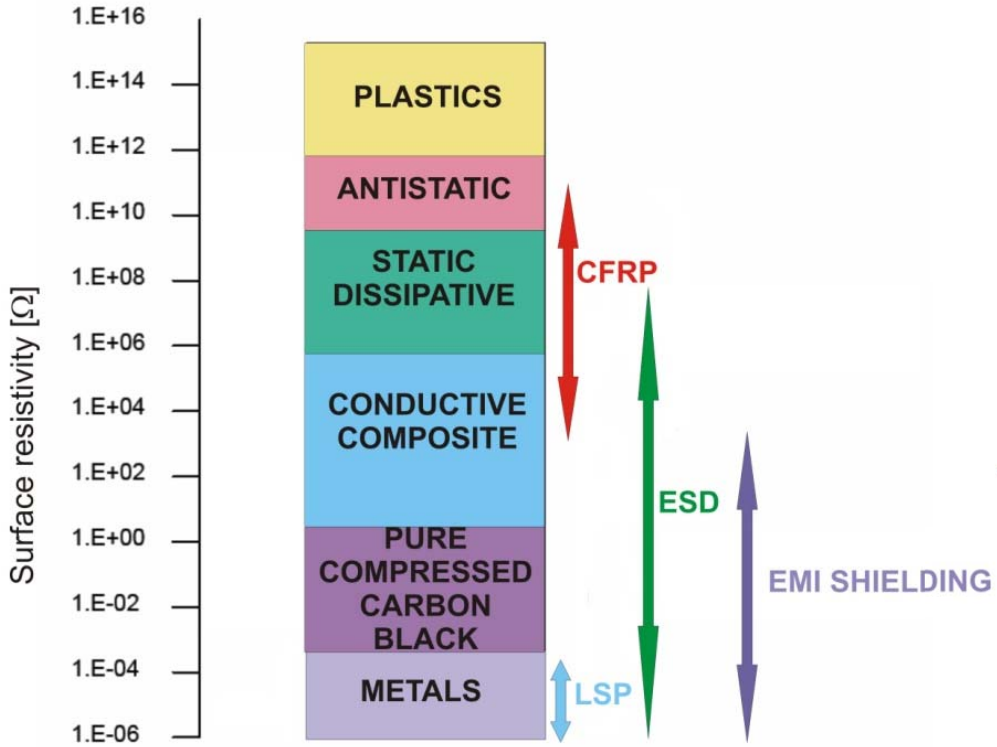
Polymer matrix composites – problem with not sufficient electrical conductivity



Aerospace

Automotive

Wind energy

INTRODUCTION TO VEILS

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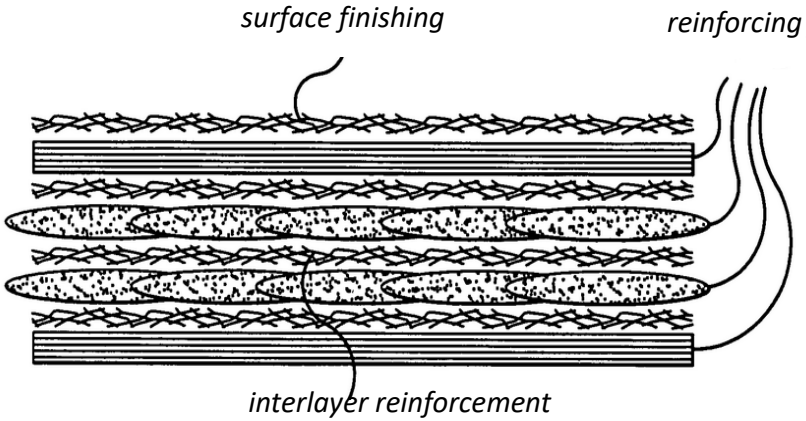
***Veils* are nonwovens with a low areal weight (GSM)** defined as sheet or web structures bonded together by entangling fiber or filaments.

They are placed as interlayers or on the top of CFRP for:

→ improvement of mechanical properties, such as fracture toughness, interlaminar shear strength and compression after impact,

→ surface finishing.



OUR SOLUTION: veils dopped with CNT

CARBON NANOTUBES

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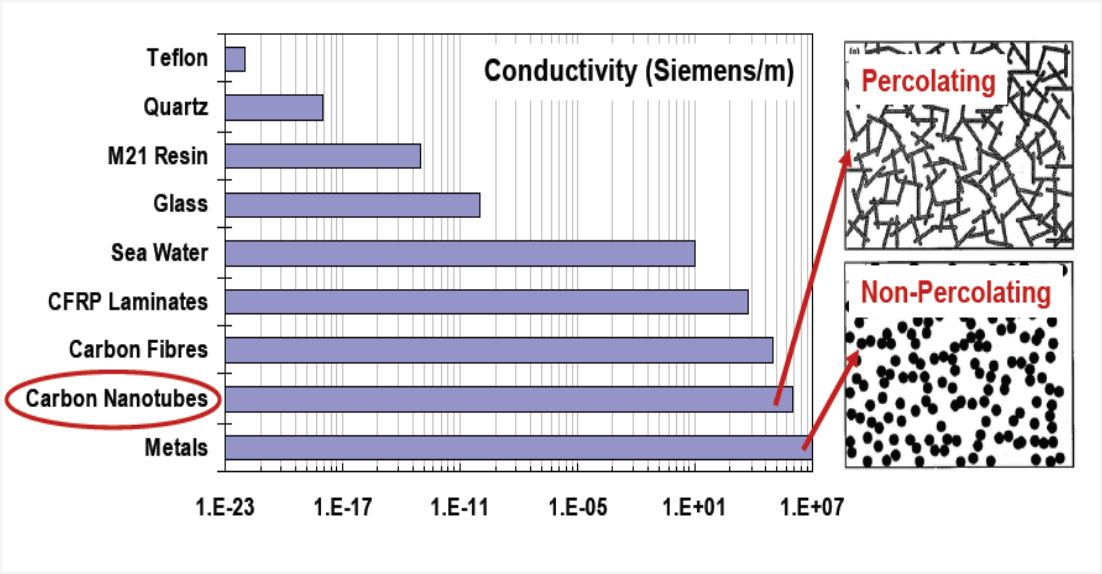

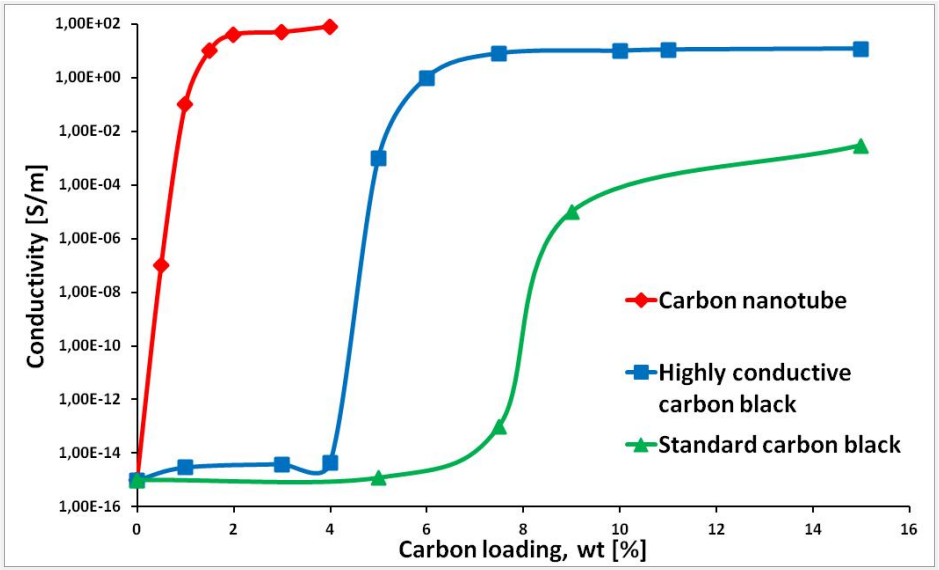

- low density: 1.3- 1.4 g/cm^3
- high tensile strength: 10÷500 GPa
- high Young's modulus: 0,3÷1,2 TPa
- high thermal conductivity: 1950 W m^{-1} K^{-1}

- low resistivity: 5÷50 μΩcm
- conduct high density current (10^9 A/cm^2)
- high aspect ratio

THERMOPLASTIC CNT-DOPED VEILS

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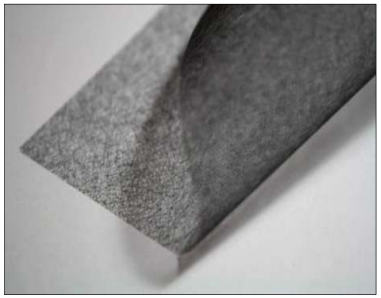
CNT-doped veils benefits:



- high flexibility and easy in handling,
- compatibility with epoxy resin
- sticky to carbon fibres and fabrics
- easy integration into standard CFRP industrial processes,
- improvement of CFRP electrical conductivity without weight increase and corrosion effect

Masterbatch + 7wt% NC7000

Selected raw materials:

1. Copolyamides – different grades, low melting point, high MFI, sticky properties
2. Nanofiller - Multi-wall Carbon nanotubes NC7000, Nanocyl, purity>95%, diameter 9.5nm, length 1.5µm

Masterbatches:

Various types of masterbatches were produced by Nanocyl using twin screw extruder.

TIMELINE OF ACTIVITIES IN VEILS DEVELOPMENT

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2009 — **2015** — **2019**

R&D | **PILOT PRODUCTION** | **COMMERCIAL ACTIVITY**

TRL4 — **TRL6** — **TRL9**

FP7 | H2020 | H2020 and beyond

TECHNOLOGY DEVELOPMENT
- Generating the knowledge
- Veils fabrication in lab scale by fibres extrusion and hot pressing

EXPLOITATION
- First contacts with the aerospace sector to identify needs in composites

PRODUCT DEVELOPMENT
- Properties
- Uniformity/Quality

PRODUCTION TECHNOLOGY
- Up-scaling of production via melt-blown
- Safety – regulations and certificates

EXPLOITATION
- Business plan
- E-Platform
- Marketing activities

PRODUCT
- Tailored to industry needs
- Product range for different applications and customers

PRODUCTION
- Up-grade to continuous line
- Increase the production capacity in industrial scale
- Safety – CE marking

EXPLOITATION
- Validate UVP with industrial companies
- Marketing and commercial activities
- Market monitoring

ELECTRICAL SARISTU

PLATFORM

OASIS

VEILS FABRICATION IN LAB SCALE (STAGE 1)

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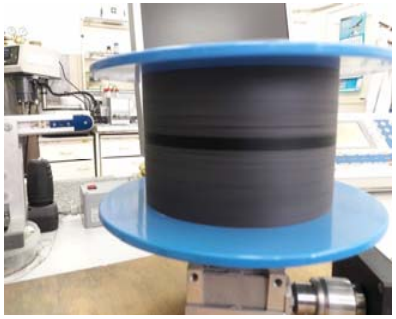
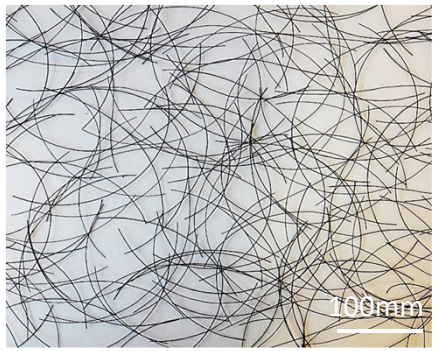
extrusion of CNT-doped fibres



winding

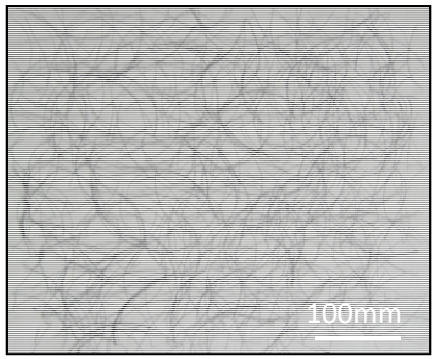
coPA + CNT fibres
d= ~ 105µm

cutting



randomly distributed short fibres

pressing



CNT-doped veil with 9 GSM

Paulina Latko, Anna Boczkowska. Patent PL 221848 B1 (2016)

POLITECHNIKA WARSZAWSKA
WARSAW UNIVERSITY OF TECHNOLOGY

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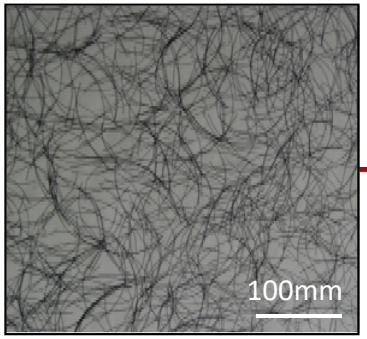
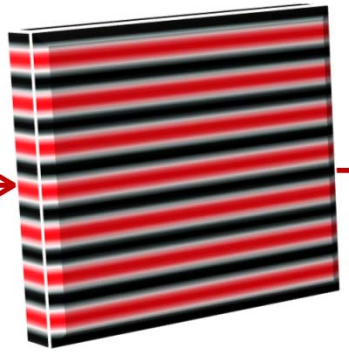
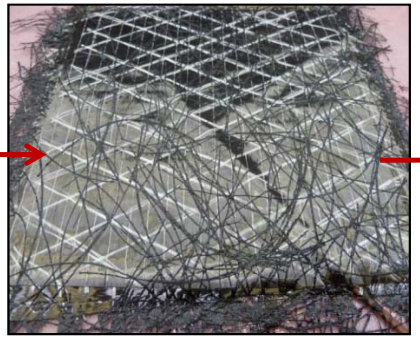
CFRP FABRICATION & CHARACTERIZATION (STAGE 1)



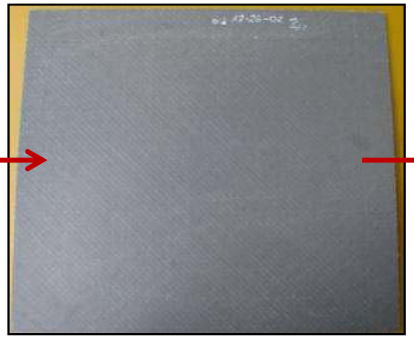
CNT-doped veil



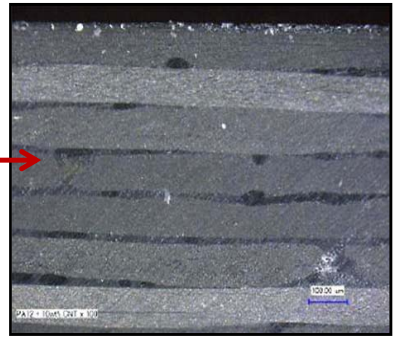
veils between layers



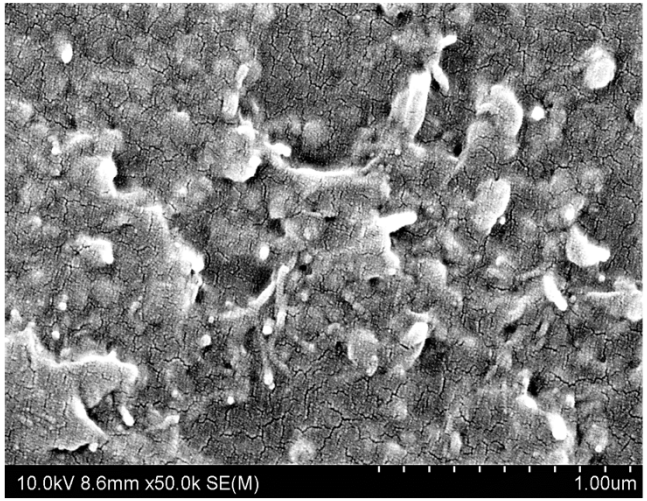
before infusion

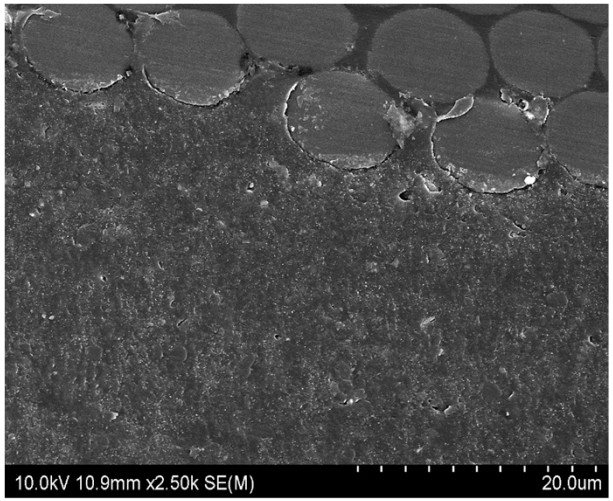


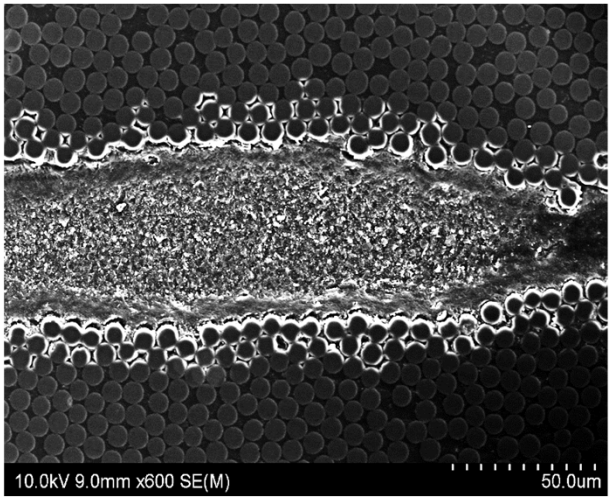
after infusion & curing



cross-section SEM image







SEM images of CFRP with inserted veils

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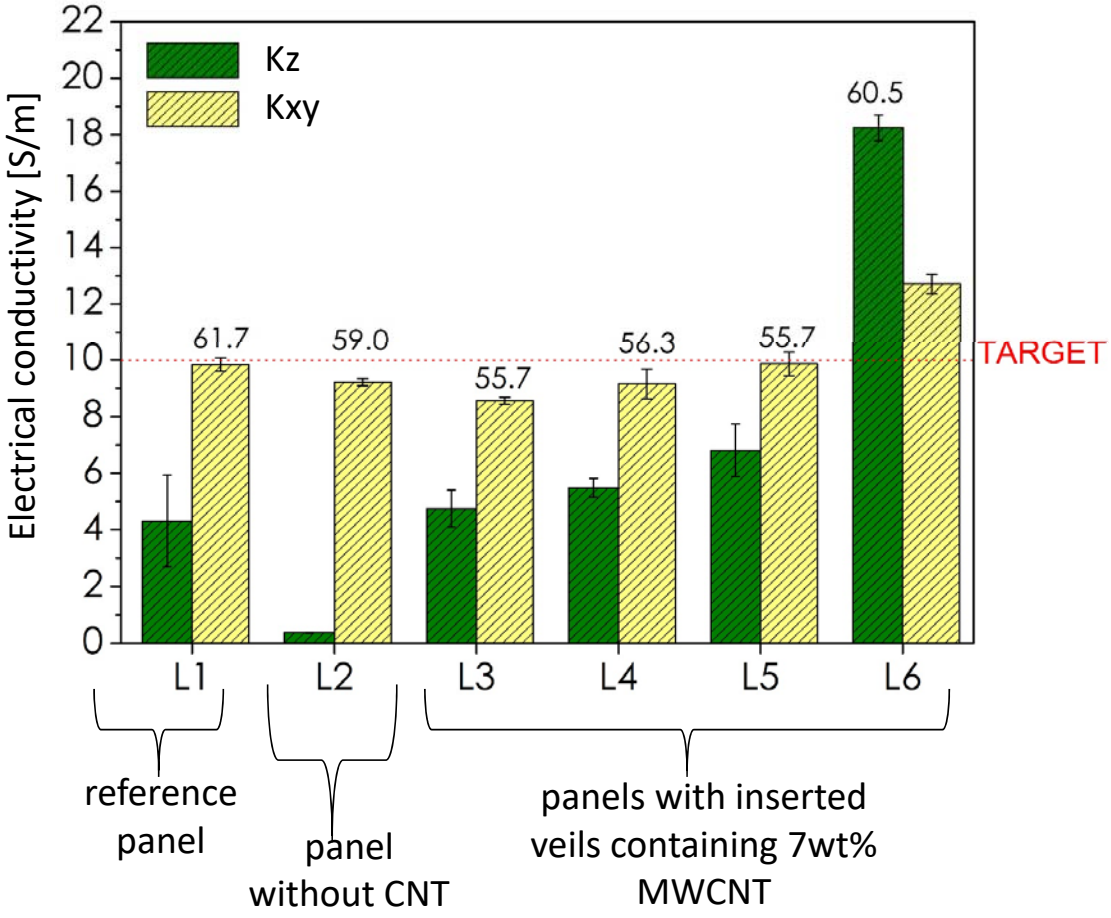
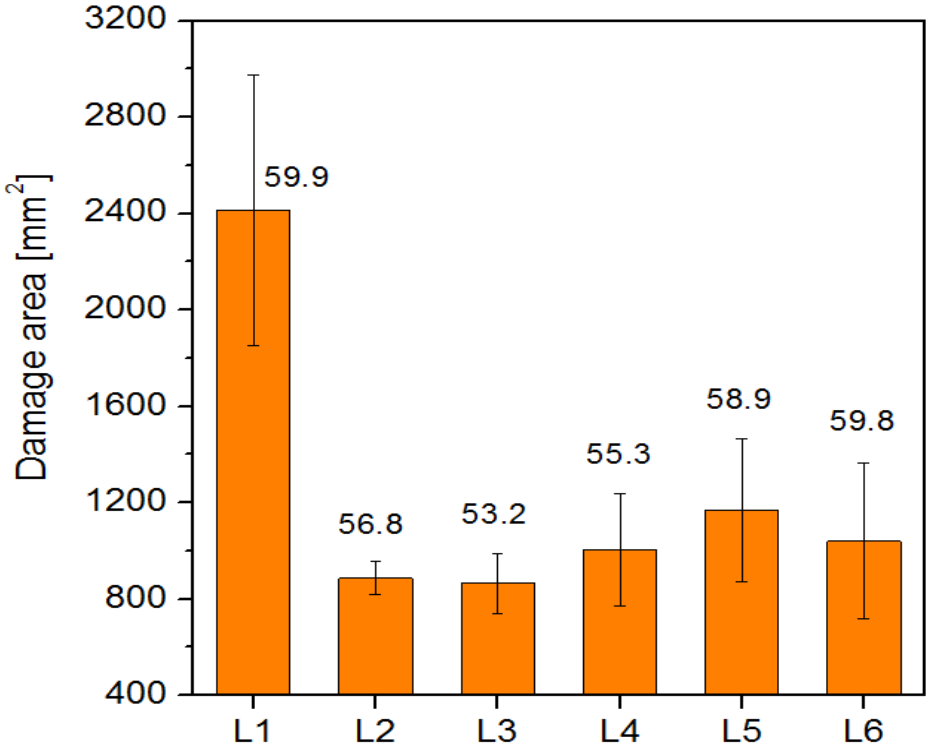
CFRP CHARACTERIZATION (STAGE 1)

Electrical conductivity



Mechanical properties



Smart Intelligent Aircraft Structures, grant: 284562

VEILS FABRICATION IN PILOT SCALE (STAGE 2)

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Melt-blown process of CNT-doped veils

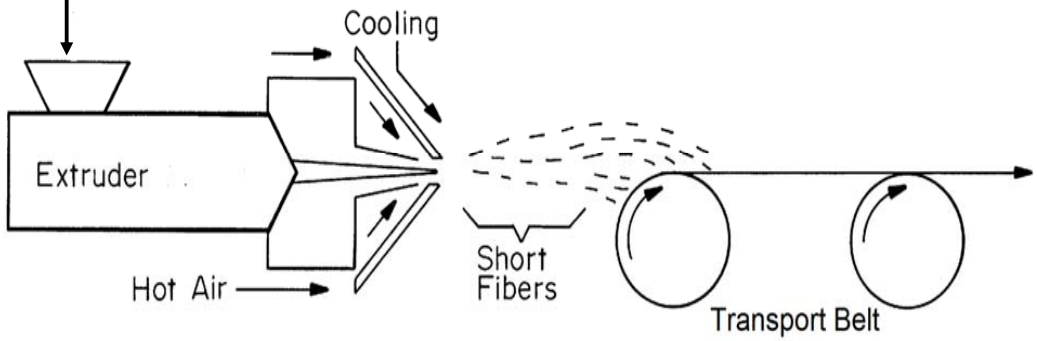
COPOLYAMIDE

half-industrial twin screw extrusion

MULTI-WALL CARBON NANOTUBES

drying

Masterbatch pellets of coPA+2.5-3.5wt% MWCNT



Melt-blowing process

VEILS FABRICATION IN PILOT SCALE (STAGE 2)

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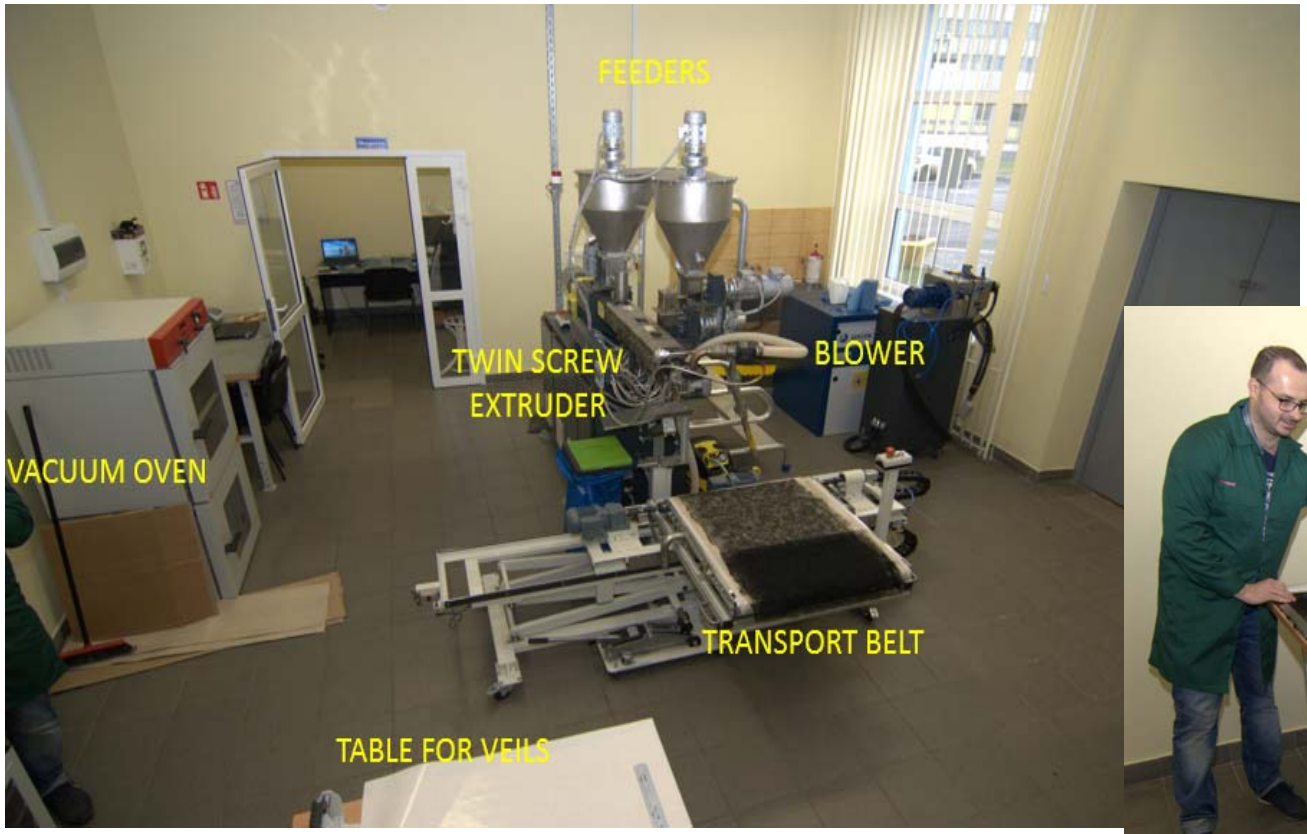

PLATFORM

Production efficiency 250 m^2 per week

VEILS FABRICATION IN PILOT SCALE (STAGE 2)

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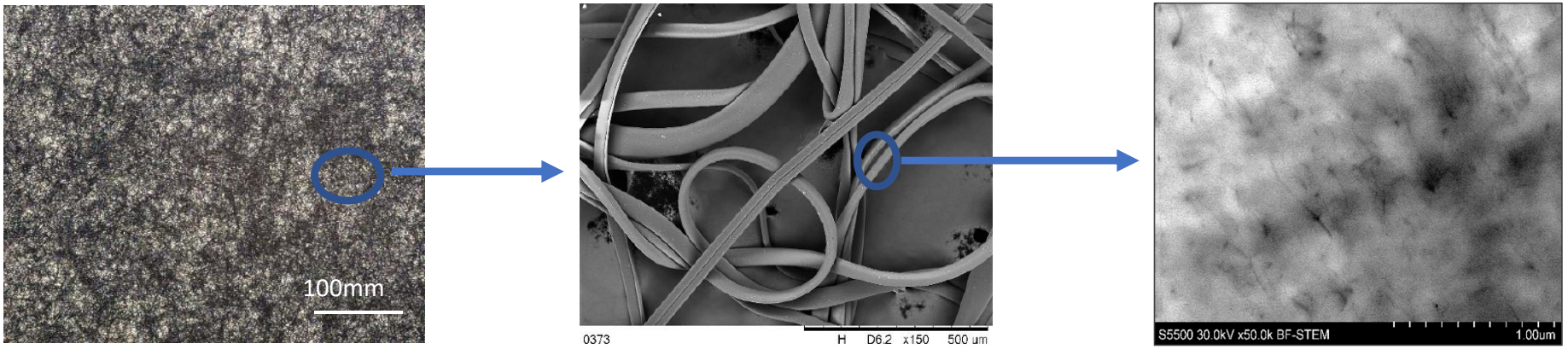
Property	Units	Value
CNT weight content	%	up to 3.5
Binders	-	none
Veil areal weight	g/m^2	15 – 200
Veil average thickness	µm	30 – 150
Fibres diameter	µm	below 70
Length	m	1.8
Width	m	0.6
Glass transition temperature	°C	~ 50
Melting point	°C	80-140
Decomposition temperature	°C	>300

SEM image of veil



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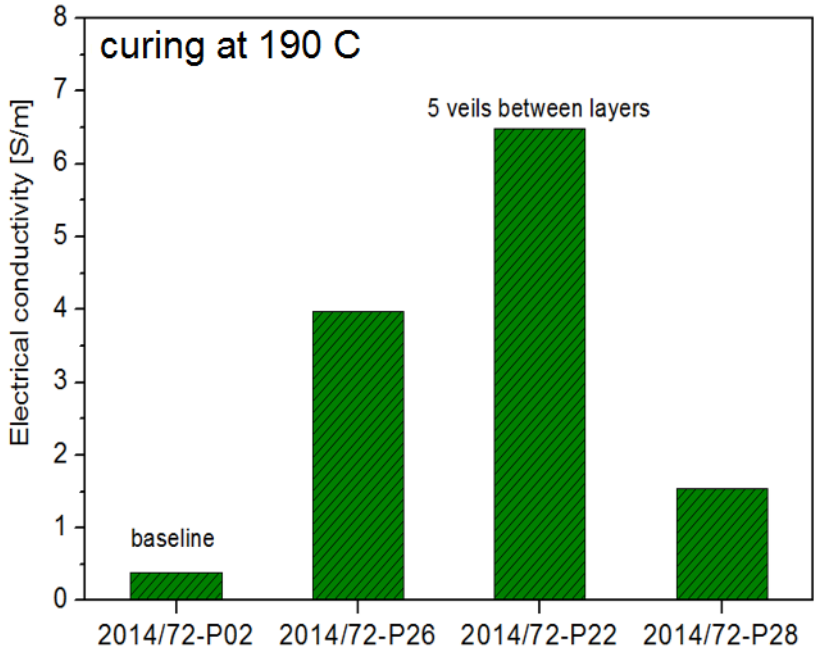
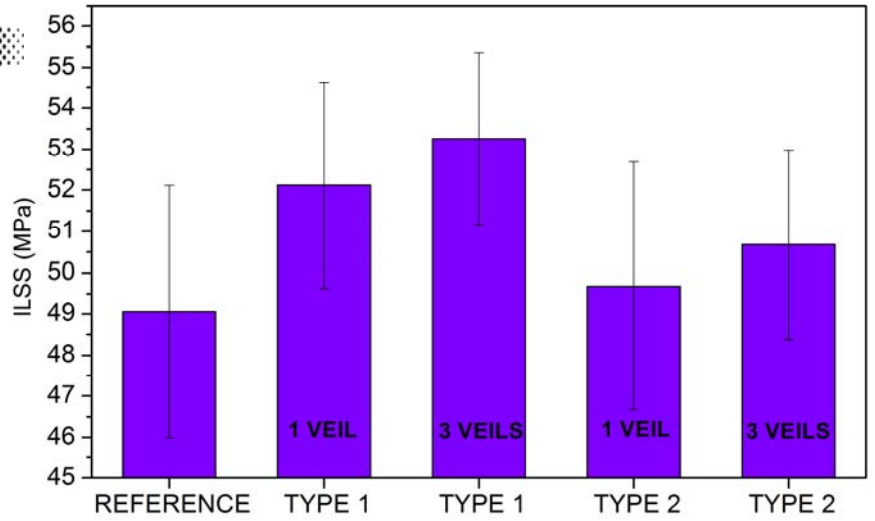
CFRP CHARACTERIZATION (STAGE 2)

CNT-doped veils were used in resin infusion process by FIDAMC

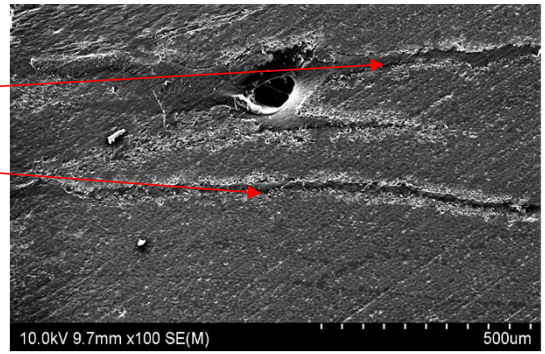
electrical conductivity in Kz direction



mechanical properties



CNT-doped veils



PLATFORM

NMP-01-2014-646307

Open access pilot plant for sustainable industrial scale nanocomposites manufacturing based on buckypapers, doped veils and prepregs

CONCEPT OF THE UPGRADED PROCESS

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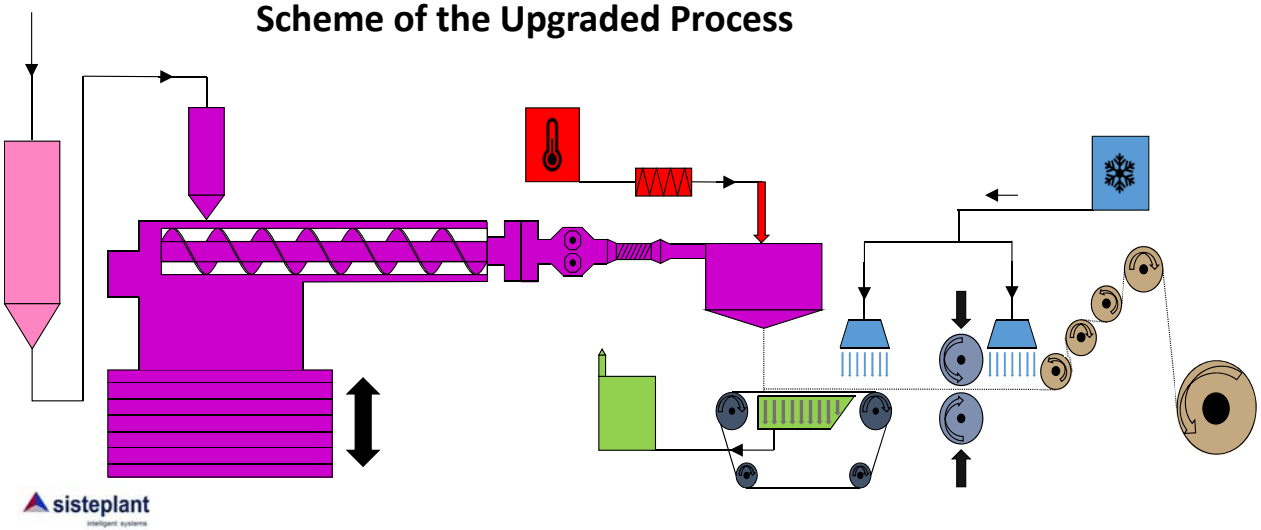
Scheme of the Upgraded Process



OASIS

Open Access Single entry point for scale-up of Innovative Smart lightweight composite materials and components - *grant agreement No 814581.*

1) Drying & Transportation System
2) Extrusion + Blowing system
3) Collection System + Suction System
4) Cooling System + Pressing System + Winding System

PROCESS PARAMETERS	
CURRENT	**FUTURE**
separate rectangular sheet with 1.9m length and 0.8m width, post-processing quality controll	continuous roll with 0.3m width, on-line quality controll
melting range of veil from 85 to 120°C depending on the type of copolyamide	also veils with melting point higher than 180°C
efficiency 250 m^2 per week	efficiency 1000m^2/week

APPLICATIONS - EXAMPLES

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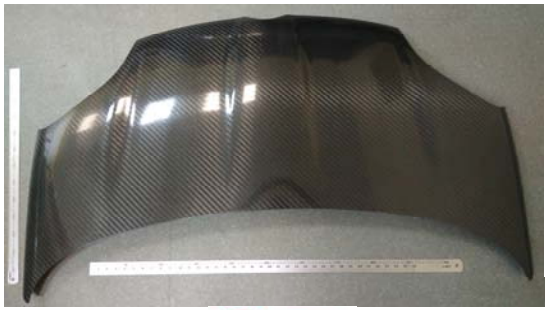
PLATFORM

CNT-doped veils provide:

electrostatic discharge to composite structures and components in the automotive and aerospace industry,

antystatic properties to composite components allowing them to be powder painted.

Composite seats



CRF CENTRO RICERCHE FIAT

Car hood

Airplane fuselage

SUMMARY

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1. **CNT-doped veils as nano enabled products for CFRP were succesfully up-scaled from lab to industrial scale.**

2. **CNT-doped veils are compatible with epoxy resin and can be easily integrated by the end users in their processess.**

3. **Implementation of CNT-doped veils in CFRP leads to the increase of electrical conductivity in Kz direction.**

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