Compositi Strutturali con Migliori Proprietà Multifunzionali Tramite l'Incorporazione di Nano Tubi di Carbonio (CNT)

Luca MEZZO

R&D and Business Development Manager

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For Nanocomposite: E. Borlatto, M. Sangermano
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Nanocyl Vision & Mission

Nanocyl aims to become the global leader in Carbon Nanotube Technologies supporting our customers in developing innovative, unique and advanced solutions at a competitive cost

High Quality and Cost Competitive Leader

We develop carbon nanotubes offering superior properties while remaining cost competitive

Total Carbon Nanotube Solutions Provider

We offer formulated carbon nanotube products to our customers that provide innovative and advanced solutions for their applications

Innovative Leader and Partner

Nanocyl is actively working with universities, research centers and industrial partners in developing new carbon nanotube-based materials which will enable our customers to successfully meet the challenges of the Third Millenium

Nanocyl R&D and Intellectual Properties

Exploration of new opportunities

- Emerging markets and new applications are creating new opportunities for CNT's
- Nanocyl participates in the whole Value Chain from listening to our customers to delivering value creation throughout the chain

R&D Team

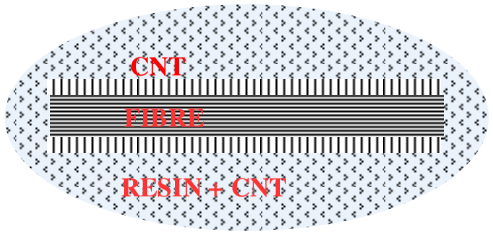
- A workforce of 21 people:
  - 8 PhDs
  - 10 engineers or equivalent
  - 2 technicians
  - 1 administrative staff member
- Large network of partners around Nanocyl (European development programs,…)

Strong Portfolio of Patents

- **8 patents have been granted in Europe, China and Japan**
- **14 inventions**
- **46 patents are pending in various regions**

The pipeline of products developed by the R&D team is growing constantly with a patent filing rate of about one application every two months

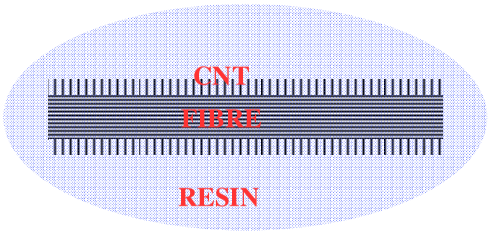
CNT in Structural Composites, Main Logic



Improved both thermal and electrical conductivities and mechanical properties (e.g. Interlaminar Shear Strength)

CNT localised at the surface of fiber (SIZICYL)

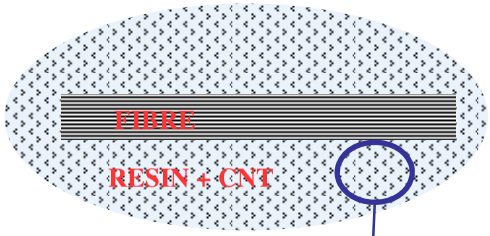
(Structural composite)



Improved mainly mechanical properties

CNT dispersed in the resine (EPOCYL)

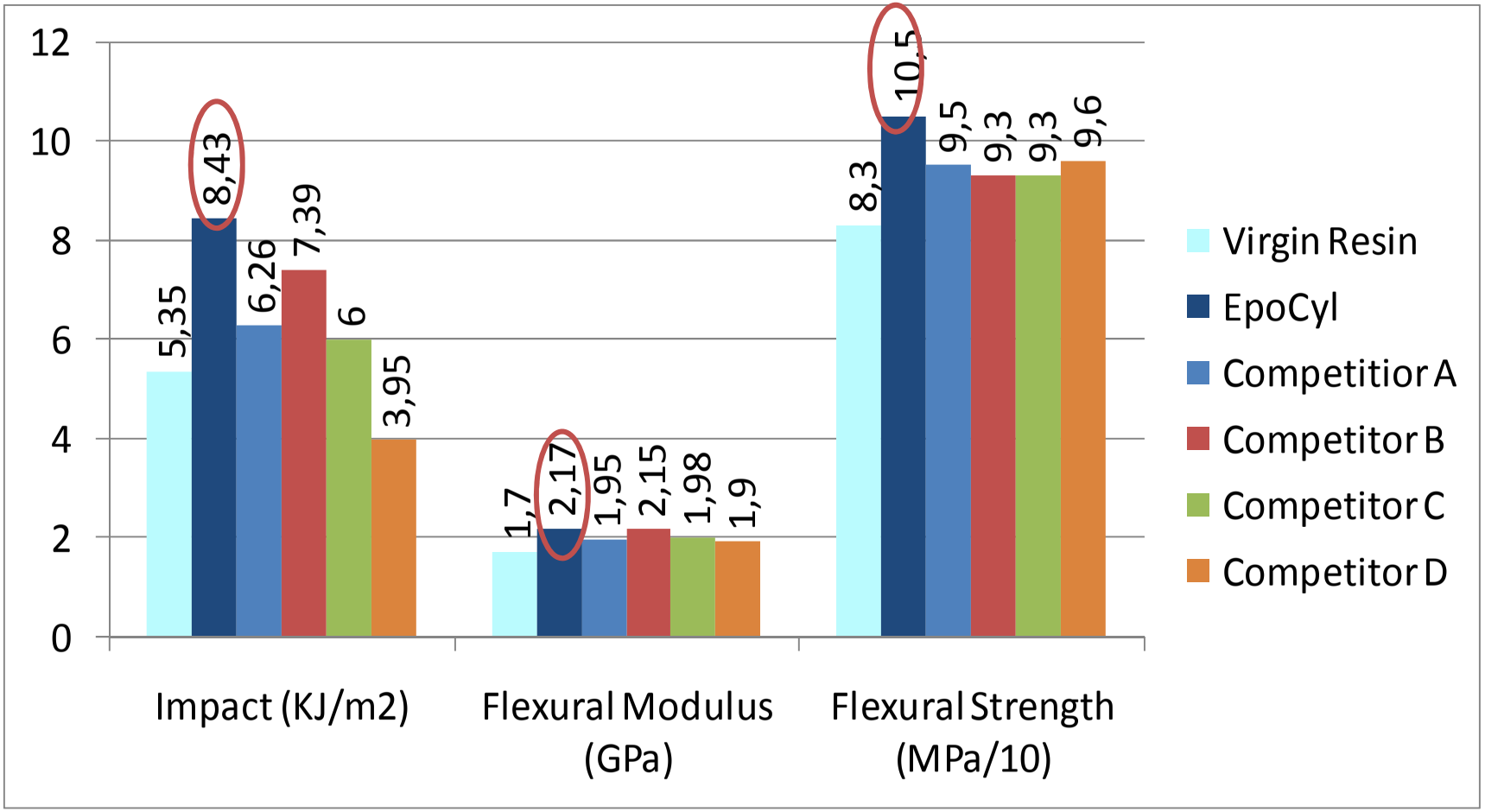
(Functional composite)



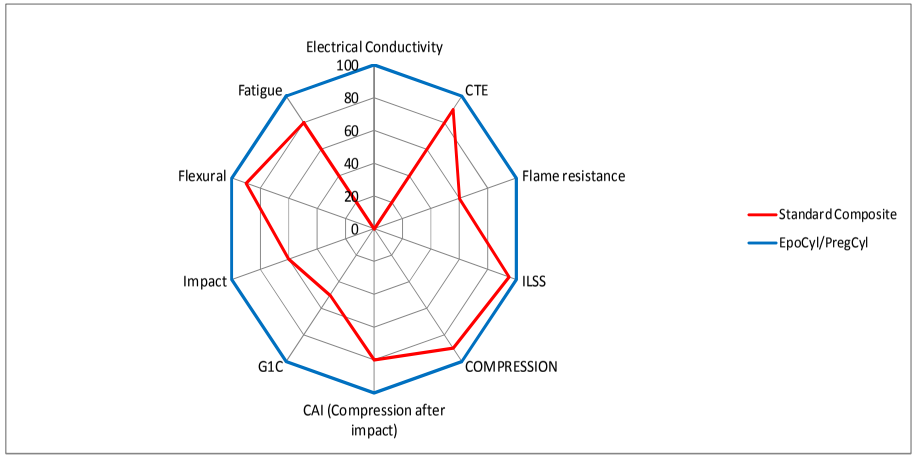
Improved mainly thermal and electrical conductivities

Nanocomposite

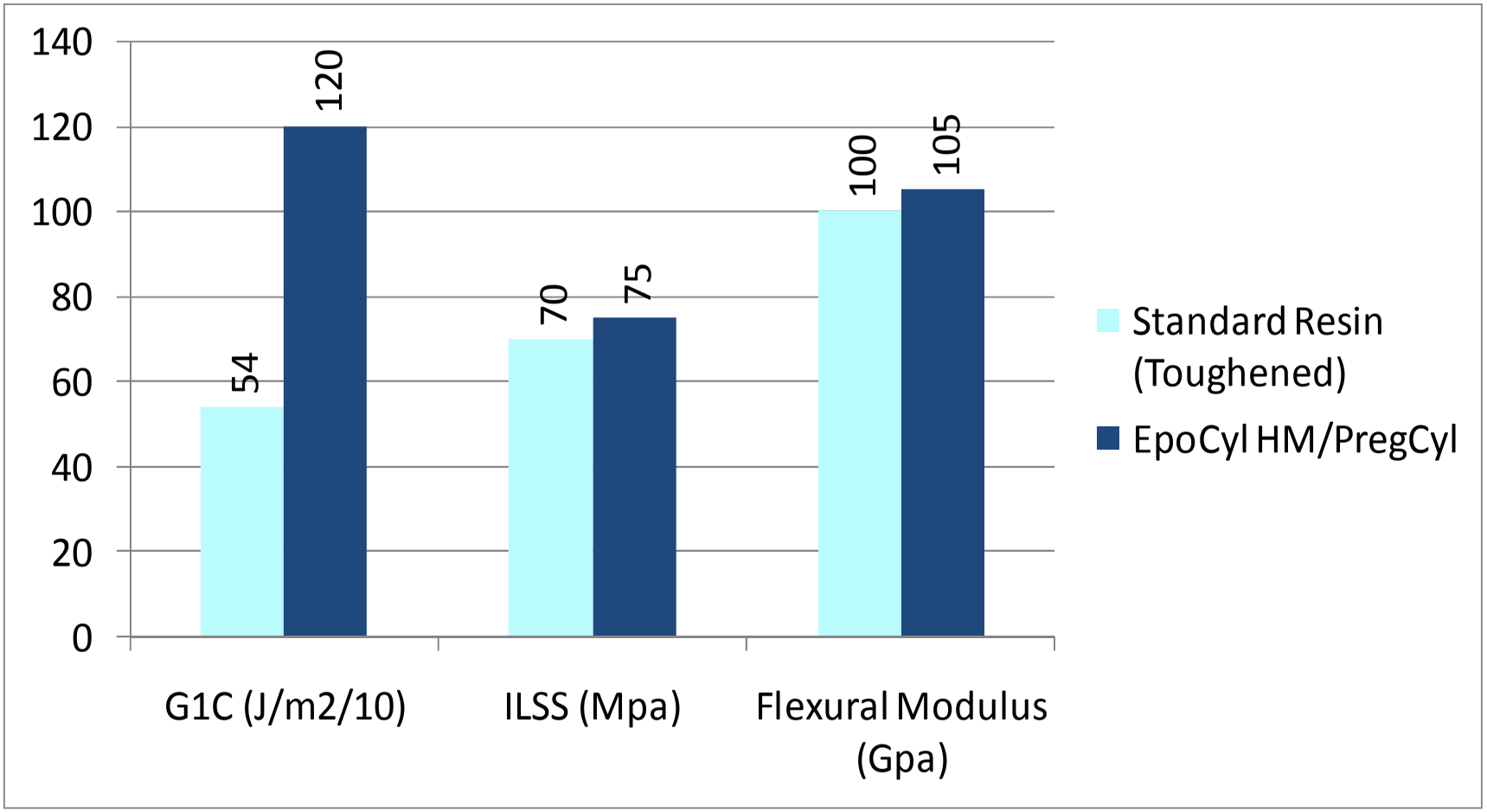
Nanocomposites (CNT+Resin), EpoCyl State of Art



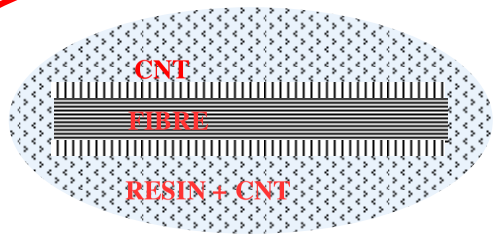
CNT in Structural Composites, EpoCyl, State of Art



CNT in Structural Composites, EpoCyl, State of Art



CNT in Structural Composites, Main Logic



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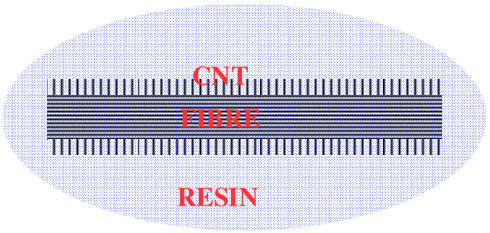
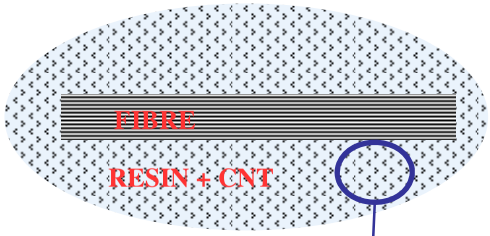
(Structural composite)



Improved mainly mechanical properties

CNT dispersed in the resine (EPOCYL)

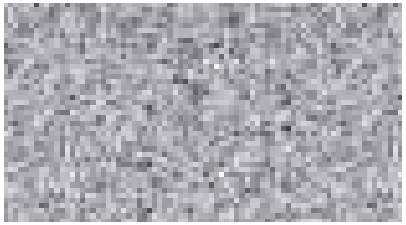
(Functional composite)



Improved mainly thermal and electrical conductivities

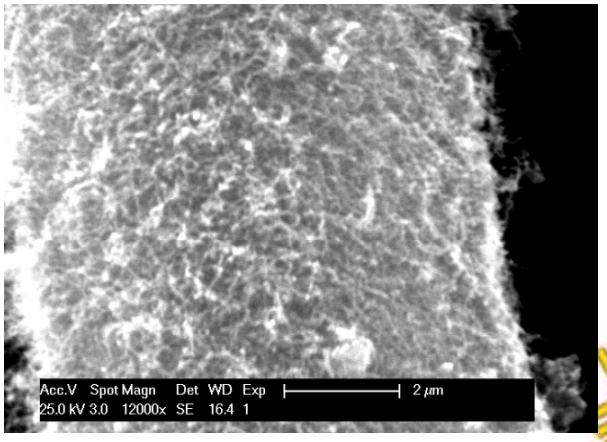
Nanocomposite

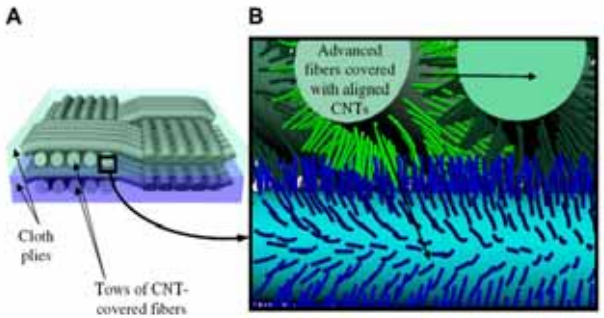
From Random CNT Distribution to CNT Placement and Orientation



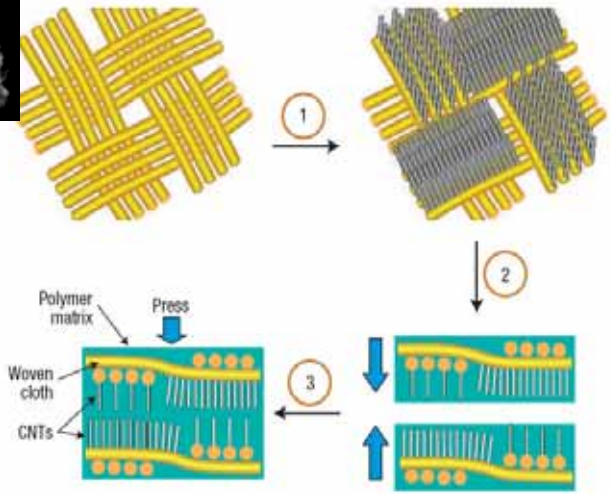
Random distribution of CNT in matrix so limited translation of the intrinsic properties of CNT to structural composites!

Short term target: Placement of CNT on the surface of the fiber





Long term target: Orientation of the CNT on the surface of the fiber and between layers



Advantages in Having CNT Localized on the Fiber's Surface

Composite properties driven by the interface fiber/matrix will be enhanced

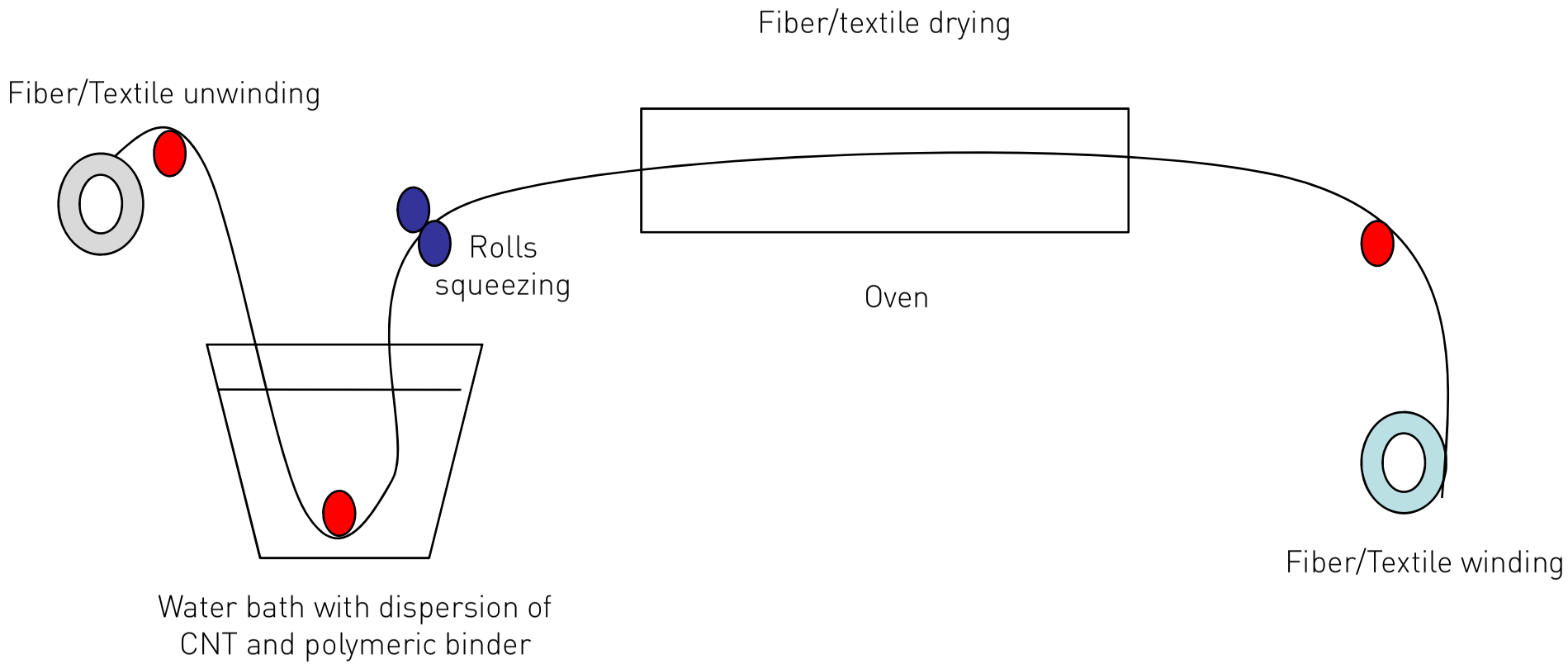
No negative influence on the resin viscosity due by the CNT >> good for RTM and Resin Infusion processes

No filtration effect done by the filaments >> uniform distribution of the CNT in the final composite part

Possibility to use any standard resin system for the impregnation >> not necessity to modify a resin formulation

To further enhance mechanical and anti-static properties required in the final composite small portion of CNT can be integrate in the matrix

Practical Process for Fiber/Textile Coating with CNT



SiziCyl, Fibers/Textiles Sized with CNT

Virgin Glass Fibers

Sized Glass Fibers (CNTs)

Patent pending

Results

Virgin Glass fibers/neat
epoxy composite

Sized Glass fibers/ neat
epoxy composite

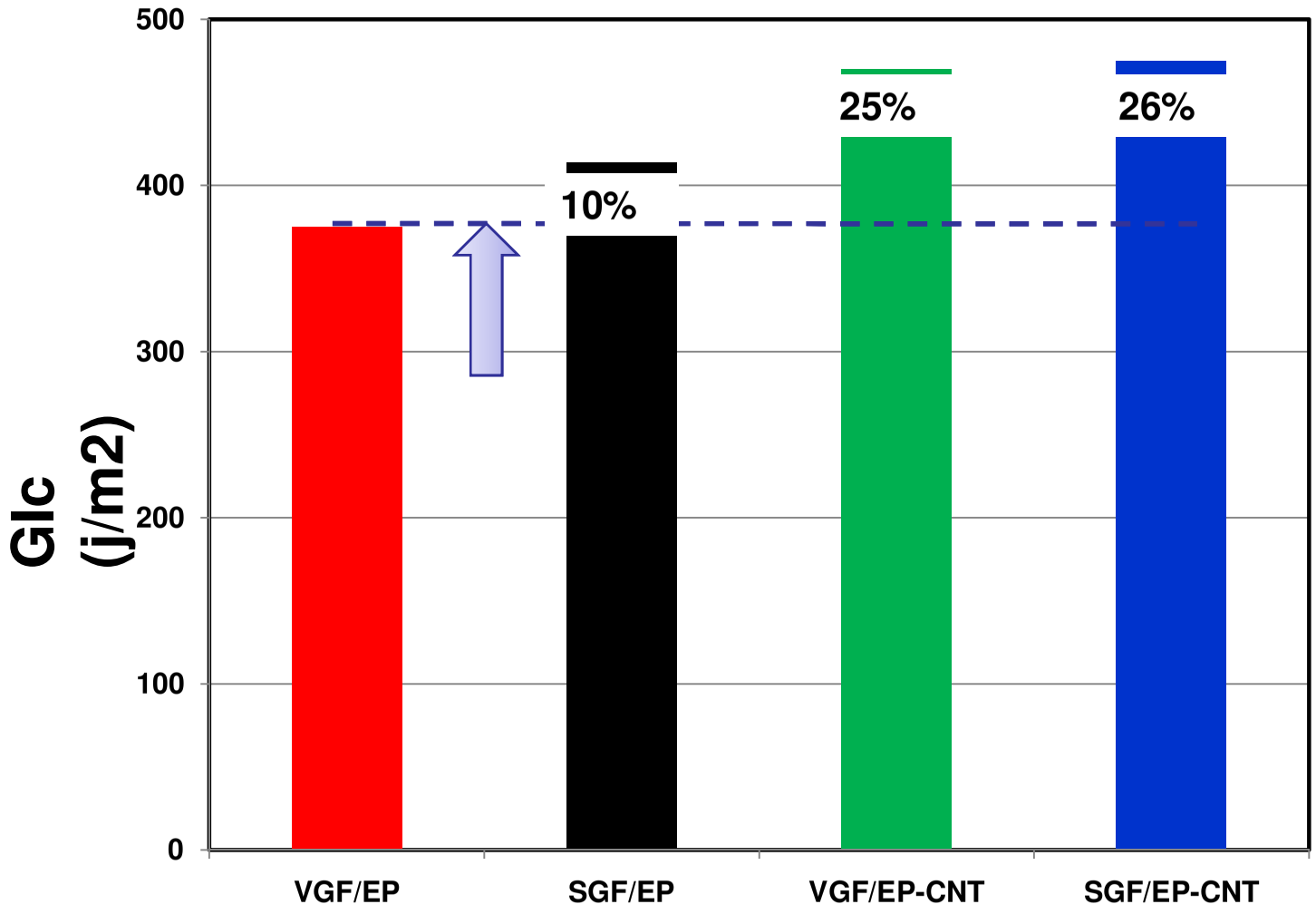
Glass fibers and epoxy
matrix with CNT composite

Composite characterization

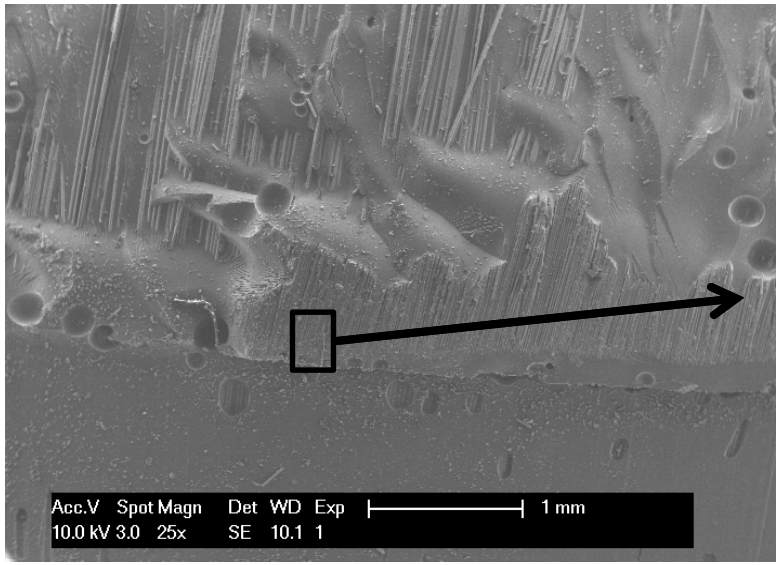
Coefficient of thermal expansion (CTE), Electrical Conductivity, Sensing Properties
Fracture toughness (GIc), and Flexural strength, interfacial shear strength (IFSS)

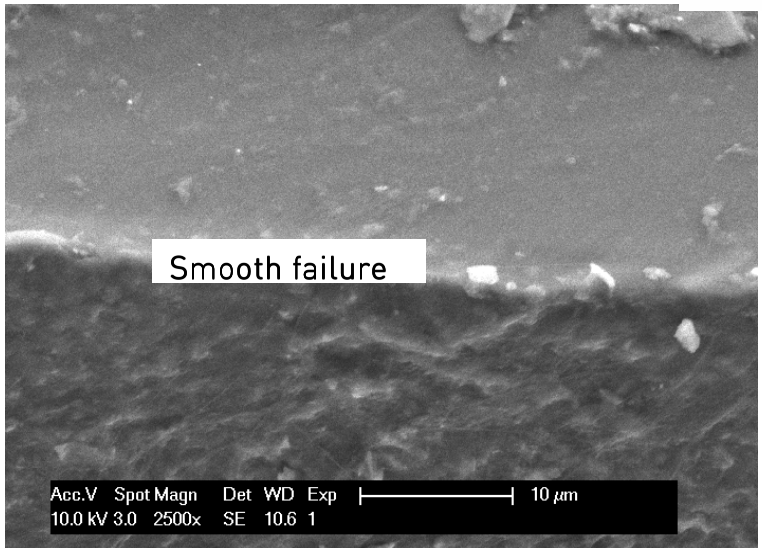
Sample code	Details
SGF	Sized Glass fiber with CNTs
VGF	Virgin Glass fiber with commercial sizing
EP	Epoxy
VGF/EP	Virgin Glass fibers with commercial sizing and neat Epoxy matrix
SGF /EP	Sized Glass fibers with CNTs and neat epoxy matrix
VGF/EPNT	Virgin Glass fibers with commercial sizing and Epoxy matrix containing CNTs
SGF/EPNT	Sized Glass fibers with CNTs and Epoxy matrix containing CNTs

SiziCyl, Fracture Toughness

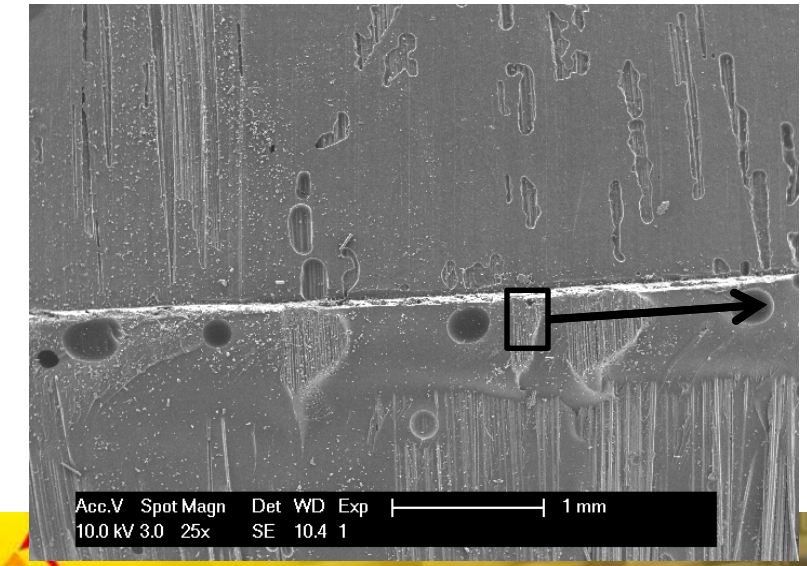


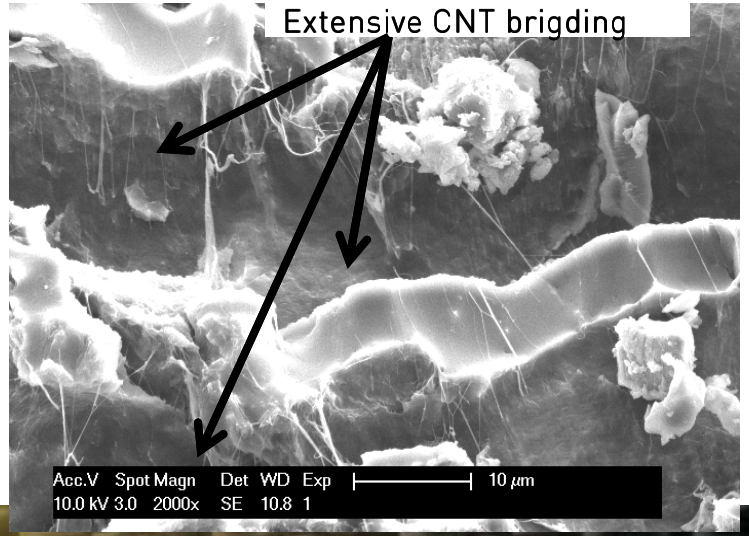
SiziCyl, Fracture Surface





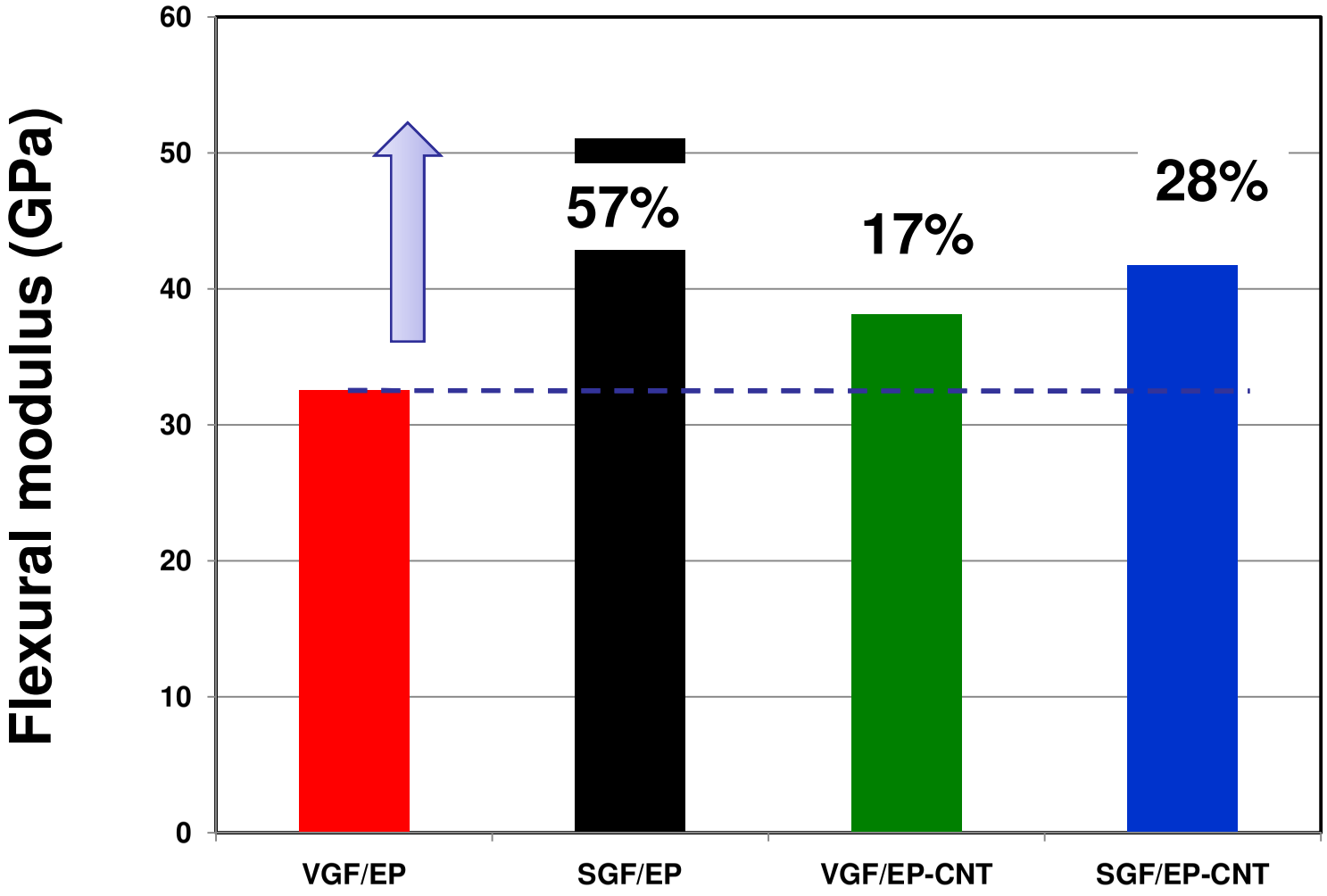
(a) VGF/EP



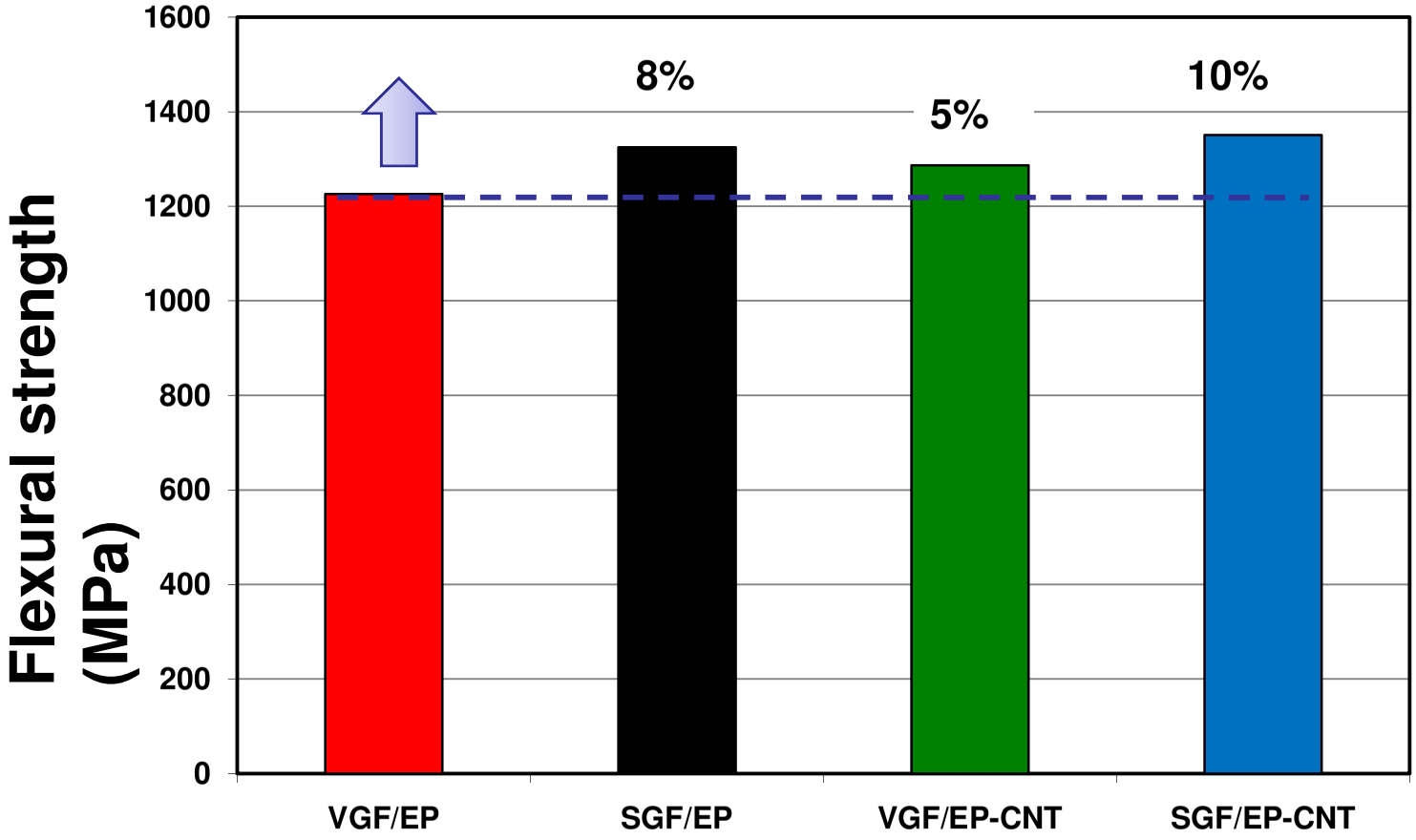


(b) VGF/EPNT

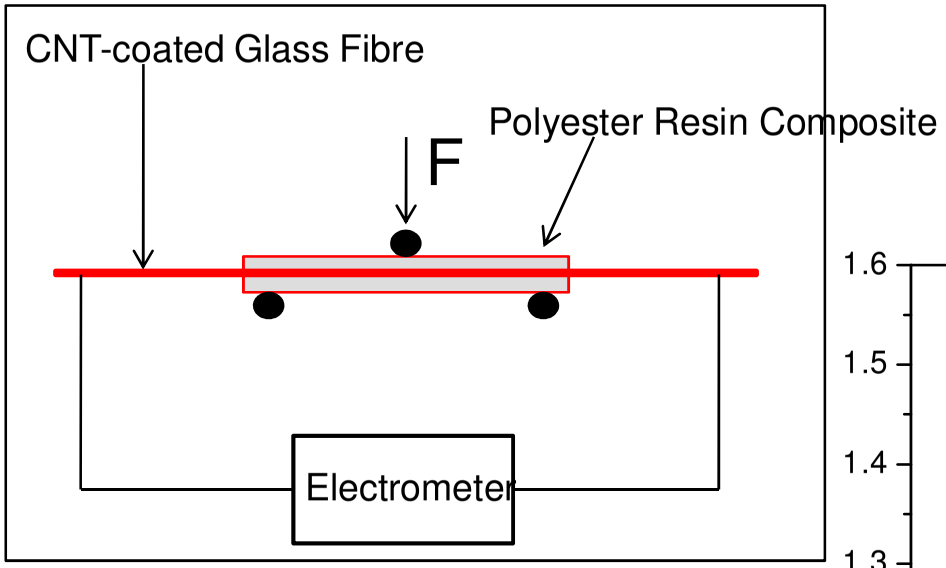
SiziCyl, 3 Points Bending Test

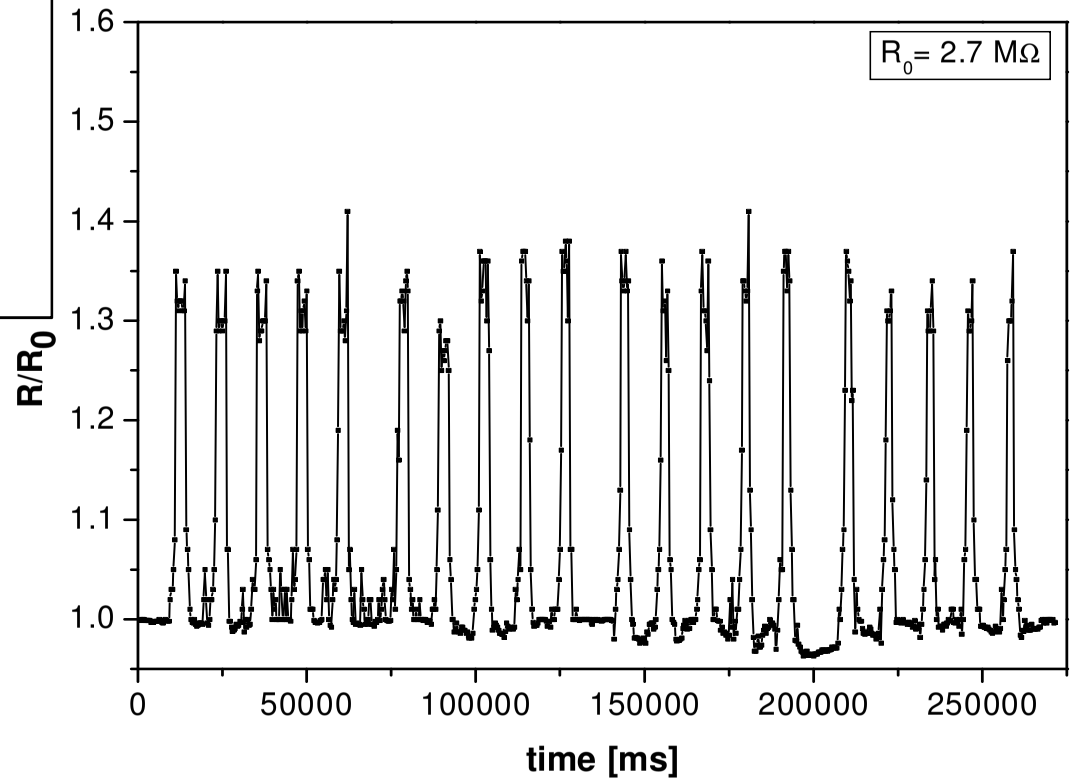


SiziCyl, 3 Points Bending Test - II

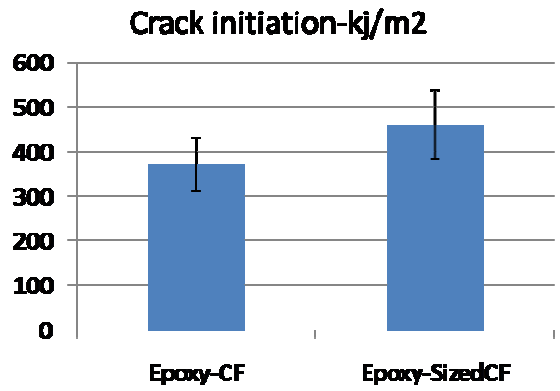


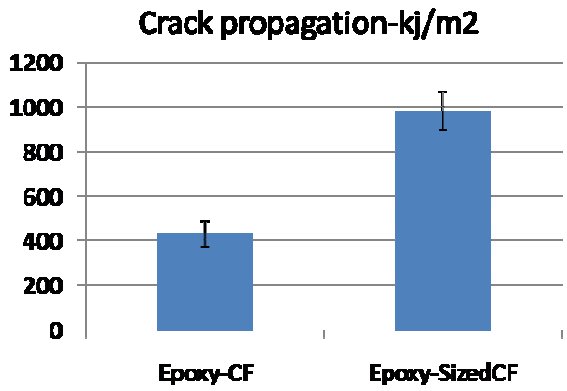
Bending strain sensitivity test on composites bas on CNT-coated Glass Fibres





SiziCyl, Fibers/Textiles Sized with CNT



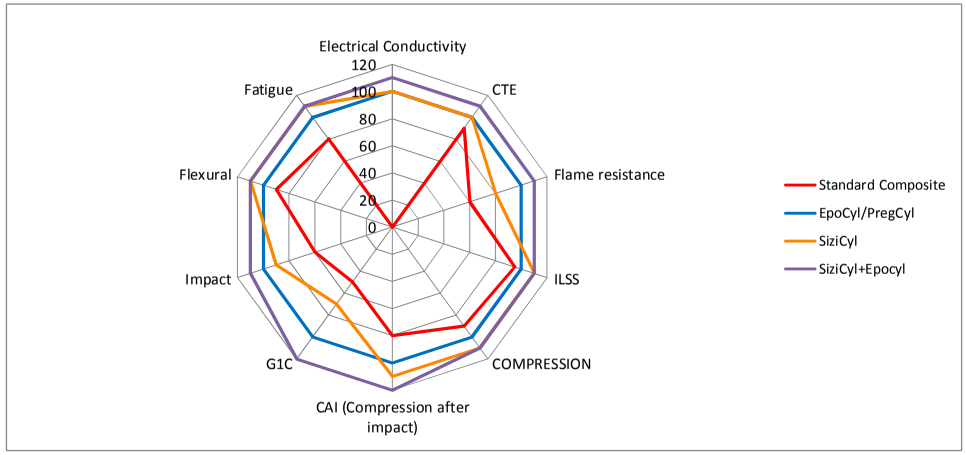


G1C Values Using Carbon Fibers

Electrical Conductivity of the Final Composite based on Insulative fibers sized with SiziCyl

	Longitudinal fiber direction	
	k ohm	k ohm/m
Epoxy-GF	overflow>10E9	
Epoxy-SGF	150	2142.857143
Phenolic-Kevlar	overflow>10E9	
Phenolic-SizedKevlar	150	2142.857143
Phenolic-GF	overflow>10E9	
Phenolic-SizedGF	120	1714.285714

CNT in Structural Composites, State of Art and Limitations



Conclusions

Surface modification of fibers by carbon nanotube based sizing is an effective way to control placement of carbon nanotube at the interface of reinforcing fibers and the matrix in structural composites.

The combination of CNT at the fiber surface (SiziCyl) and the CNT in the matrix (EpoCyl) allow to well optimize both mechanical and functional properties

As the product are the very early stage of the development, the results show huge scope to improve thermo - mechanical performance of structural composites.

Thank You

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