Introduction and conclusion sections

Dr. Georgios Tzortzinis

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Case study

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CNT Enabled Co-braided Smart Fabrics: A New Route for Non-invasive, Highly Sensitive & Large-area Monitoring of Composites

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Sida Luo[1,2], Yong Wang[1], Guantao Wang[1,3], Kan Wang[4], Zhibin Wang[5], Chuck Zhang[4], Ben Wang[4], Yun Luo[3], Liuhe Li[1] & Tao Liu[2]

The next-generation of hierarchical composites needs to have built-in functionality to continually monitor and diagnose their own health states. This paper includes a novel strategy for *in-situ* monitoring the processing stages of composites by co-braiding CNT-enabled fiber sensors into the reinforcing fiber fabrics. This would present a tremendous improvement over the present methods that excessively focus on detecting mechanical deformations and cracks. The CNT enabled smart fabrics, fabricated by a cost-effective and scalable method, are highly sensitive to monitor and quantify various events of composite processing including resin infusion, onset of crosslinking, gel time, degree and rate of curing. By varying curing temperature and resin formulation, the clear trends derived from the systematic study confirm the reliability and accuracy of the method, which is further verified by rheological and DSC tests. More importantly, upon wisely configuring the smart fabrics with a scalable sensor network, localized processing information of composites can be achieved in real time. In addition, the smart fabrics that are readily and non-invasively integrated into composites can provide life-long structural health monitoring of the composites, including detection of deformations and cracks.

Fiber-reinforced polymeric composites (FRPs) are remarkably important as structural materials for a wide variety of applications such as commercial & battle aircrafts, jet engine, wind turbine, gas and oil transmission pipelines etc. Since the last decade, substantial attention has been paid for the research and development of next generation of FRPs with built-in multifunctionality for self-sensing, identifying, quantifying and deciding their own health states[1,2]. In one aspect, different approaches were attempted to impart the FRPs with capabilities for structural health monitoring (SHM) during different stages of their life cycle[3,4]. For examples, SMARTweave[5], optical fiber[6,7], time domain reflectometry[8], thermometer[9], ultrasonic[10], and pressure transducers[11] have been used in the manufacturing stage of FRPs for resin infusion and curing monitoring. Similarly, optical fiber[12], eddy-current[13], piezoelectric[14] and magnetostrictive sensors[15] were used in the service stage of FRPs for deformation and crack detections.

As compared to the above mentioned traditional methods, carbon nanotubes (CNTs) enabled *in-situ* SHM technology has attracted a considerable amount of attention by virtue of their excellent mechanical robustness, non-invasive embeddability and conformability, light weight, low cost in fabrication and implementation, and remarkably high piezoresistive sensitivity[16,17]. Different types of CNT sensors have been explored, e.g., by bridging CNTs onto fiber and matrix interface as 1D sensors[18,19], by depositing CNTs to formats of thin films or buckypapers as 2D sensors[20–23] or by distributing CNTs directly in the resin matrix to form 3D sensors[24,25]. In most cases, the working principle of CNT sensors relies on the tunneling resistance change of the percolated CNT network upon external stimulus to impart the sensors with the capability for monitoring different mechanical

[1]Beihang University, School of Mechanical Engineering & Automation, International Research Institute for Multidisciplinary Science, Beijing, 100191, China. [2]Florida State University, High Performance Materials Institute, Tallahassee, 32310, USA. [3]China University of Geosciences, Center of Safety Research, Beijing, 100083, China. [4]Georgia Institute of Technology, H. Milton Stewart School of Industrial and Systems Engineering, Atlanta, 30332, USA. [5]Stanford University, School of Medicine, Stanford, 94305, USA. Correspondence and requests for materials should be addressed to S.L. (email: s.luo@buaa.edu.cn) or T.L. (email: tliu@fsu.edu)

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Quick luck

Define Abbreviations

References

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Citation Styles

APA in-text

Author type	Parenthetical citation	Narrative citation
One author	(Luna, 2020)	Luna (2020)
Two authors	(Salas & D'Agostino, 2020)	Salas and D'Agostino (2020)
Three or more authors	(Martin et al., 2020)	Martin et al. (2020)
Group author with abbreviation First citation [a] Subsequent citations	 (National Institute of Mental Health [NIMH], 2020) (NIMH, 2020)	 National Institute of Mental Health (NIMH, 2020) NIMH (2020)
Group author without abbreviation	(Stanford University, 2020)	Stanford University (2020)

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IEEE in-text

"... as shown by Brown [4], as previously stated."

"The theory was first put forward in 1987 [1]."

"For example, see [7]."

"Several recent studies [3, 4, 15, 16] have suggested that..."

[bath.ac.uk]

Citation Styles

APA

Book

- Jackson, L. M. (2019). The psychology of prejudice: From attitudes to social action (2nd ed.). American Psychological Association. https://doi.org/10.1037/0000168-000

Conference Paper

- Duckworth, A. L., Quirk, A., Gallop, R., Hoyle, R. H., Kelly, D. R., & Matthews, M. D. (2019). Cognitive and noncognitive predictors of success. Proceedings of the National Academy of Sciences, USA, 116(47), 23499–23504. https://doi.org/10.1073/pnas.1910510116

Periodicals

- Grady, J. S., Her, M., Moreno, G., Perez, C., & Yelinek, J. (2019). Emotions in storybooks: A comparison of storybooks that represent ethnic and racial groups in the United States. Psychology of Popular Media Culture, 8(3), 207–217. https://doi.org/10.1037/ppm0000185

[apastyle.apa.org]

IEEE

- J. K. Author, “Title of chapter in the book,” in Title of Published Book, xth ed. City of Publisher, (only U.S. State), Country: Abbrev. of Publisher, year, ch. x, sec. x, pp. xxx–xxx.

- J. K. Author, “Title of paper,” presented at the Abbreviated Name of Conf., City of Conf., Abbrev. State, Country, Month and day(s), year, Paper number.

- J. K. Author, “Name of paper,” Abbrev. Title of Periodical, vol. x, no. x, pp. xxx-xxx, Abbrev. Month, year.
- J. K. Author, “Name of paper,” Abbrev. Title of Periodical, vol. x, no. x, pp. xxx-xxx, Abbrev. Month, year, doi: xxx.

[ieee.org]

Case study

Paragraph structure

Fiber-reinforced polymeric composites (FRPs) are remarkably important as structural materials for a wide variety of applications such as commercial & battle aircrafts, jet engine, wind turbine, gas and oil transmission pipelines etc. Since the last decade, substantial attention has been paid for the research and development of next generation of FRPs with built-in multifunctionality for self-sensing, identifying, quantifying and deciding their own health states[1,2]. In one aspect, different approaches were attempted to impart the FRPs with capabilities for structural health monitoring (SHM) during different stages of their life cycle[3,4]. For examples, SMARTweave[5], optical fiber[6,7], time domain reflectometry[8], thermometer[9], ultrasonic[10], and pressure transducers[11] have been used in the manufacturing stage of FRPs for resin infusion and curing monitoring. Similarly, optical fiber[12], eddy-current[13], piezoelectric[14] and magnetostrictive sensors[15] were used in the service stage of FRPs for deformation and crack detections.

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FRPs

Multifunctional FRPs

Specific cases

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Paragraph structure

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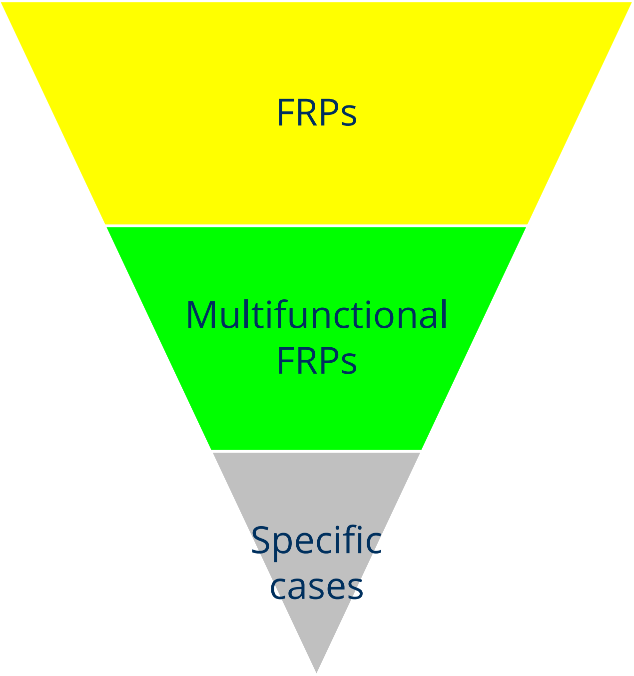

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Cohesion in a paragraph

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Coherence between paragraphs:

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At this stage, the attendees were provided with the introduction section of a second published academic paper.

First paragraph

- **1st Paragraph Decomposition**:
  - -> -> -> -> ->

- **Problem statement**:

- **Linking/transition words**:

Second paragraph

- **2nd Paragraph Decomposition**:
  - -> -> -> ->

- **Paragraph overview**:

- **Linking/transition words** :

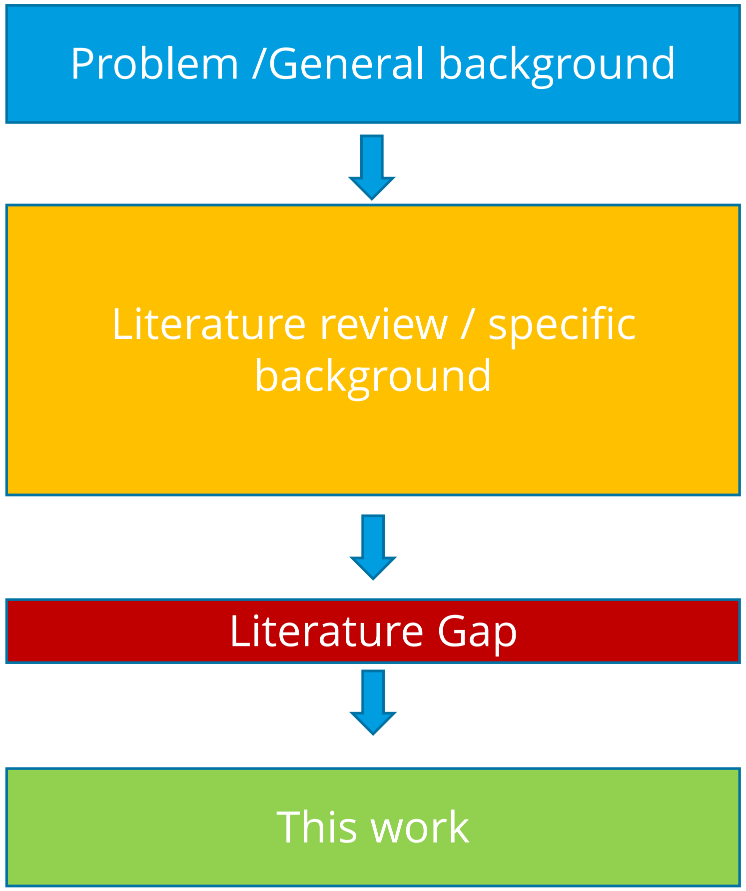
Sixth Paragraph

- **Research Goal:**
- **How is cohesion ensured?**
- **Materials:**
- **Methodology:**
- **Results:**

Introduction

Key point of each paragraph

- 1st:
- 2nd:
- 3rd:
- 4th:
- 5th:
- 6th:



Introduction

Transition between paragraphs

- 1st-2nd:
- 2nd-3rd: ‘
- 3rd-4th:
- 4th-5th:
- 5th-6th:

Useful phrases

Highlighting inadequacies of previous studies

Previous studies of X have not dealt with …
Researchers have not treated X in much detail.
Such expositions are unsatisfactory because they …
Most studies in the field of X have only focused on …
Such approaches, however, have failed to address …
Previous published studies are limited to local surveys.
Half of the studies evaluated failed to specify whether …
The research to date has tended to focus on X rather than
published studies on the effect of X are not consistent.

Introducing the critical stance of particular writers

However, Jones (2015) points out that …
The author challenges the widely held view that …
Smith (1999) takes issue with the contention that …
The idea that … was first challenged by Smith (1992).

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The conclusion section

Conclusion

- Restate the problem statement addressed in the paper
- Relate your major findings to the problem statement and specific objectives (check introduction)
- Mention limitations
- Specific recommendations for future research

You may have a stand-alone conclusions section or include your conclusions in a subsection of your discussion or results and discussion section.

Remember: Very view people will read the whole paper!

Practise: Research Task 1 of the COMP-ECO project

Objectives

<u>Strip level investigation</u>

- Establish understanding of the CNT effect on the mechanical and electrical response of matrix materials.

- Selection of the optimal CNT-doped strip (materials, geometry, wt) for implementation as a strain sensor.

<u>Structure level investigation</u>

- Development of CNT-doped strips based strain sensors concepts in a GFRP structure;

- Connectivity of CNT-doped strips (in collaboration with Subtask 6) ;

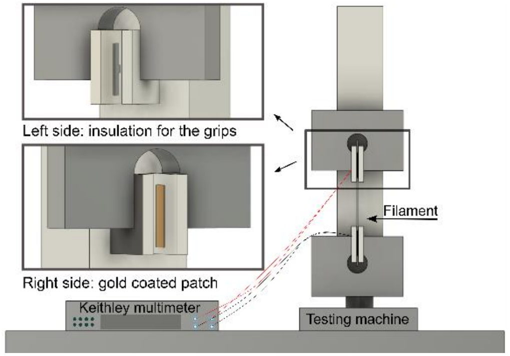
- Evaluation of CNT-doped strip as sensor within a GFRP structure;

Practise: Research Task 1 of the COMP-ECO project

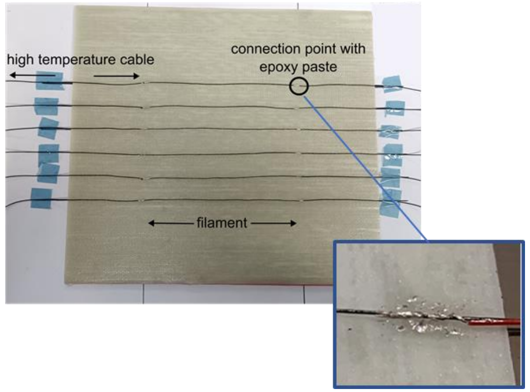
Description

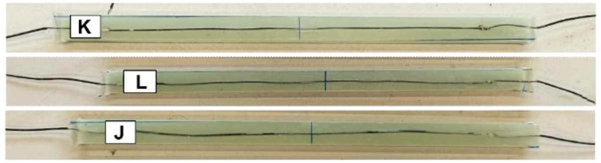
CNT-doped strips

Filament Characterization

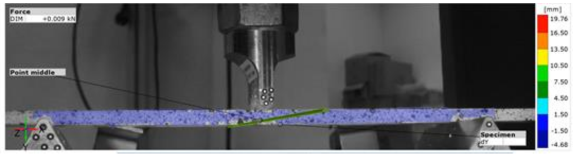


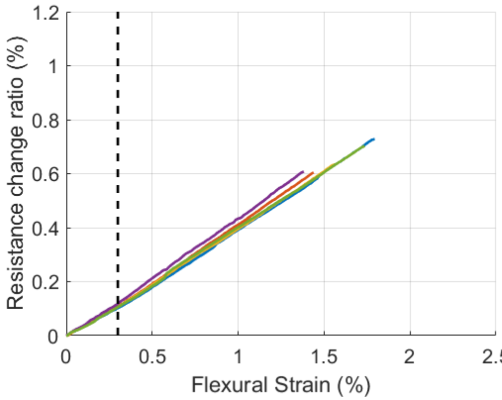
Specimen manufacturing





Testing





Structure of the Introduction

Title: Strain sensing of CFRP structures by integrated piezoresistive CNT-doped strips

1st paragraph: → →

2nd paragraph: → →

3rd paragraph: → →

4th paragraph: → →