NC STATE
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Textile Processable Carbon Nanotube Yarn for Smart Textiles

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Advancing Carbon Nanotube Textiles

Core Objectives
- Produce electrically conductive carbon nanotube wrapped textile yarns
- Design and develop smart textiles with multifunctional properties

Significant Achievement
- Successfully produced flexible, and strong carbon nanotube yarns
- Developed multifunctional smart textiles using the conductive yarns

WHY CNT IN E-TEXTILES?

Characteristics

Background

- E-textiles is thriving, and expected compound annual growth rate (CAGR) is 32% by 2023
- High demand for flexible and soft electronics Easy processability of conductive yarn to integrate into textiles
- Development of internet of thing and demand for connected devices

Industry Expectations of E-textiles

- Design flexibility and effortless shaping
- Textile processable by existing techniques
- Aesthetic appeal and comfort
- Wash durability

CNT WRAPPED YARNS

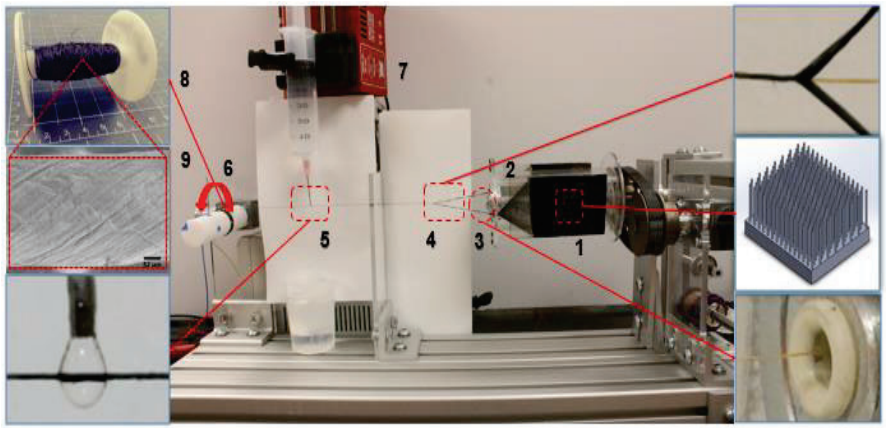

Figure: Spinning process 1.Vertically aligned CNT 2. CNT sheet, 3.Core yarn insertion, 4.CNT wrapping, 5.TPU coating, 6.Winding, 7.Syringe pump, 8.Yarn spool, 9.SEM image of yarn

MORPHOLOGY OF YARNS

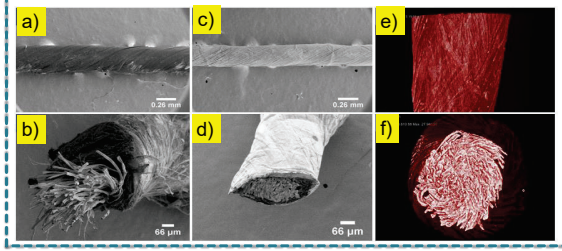

Figure: SEM and Nano X-ray images of the yarns: a) CNT-Cotton b) Cross-section of CNT-Cotton c) CNT-Cotton-TPU d) Cross-section of CNT-Cotton-TPU
Nano X-ray of CNT-Cotton-TPU:
e) Longitudinal f) Cross-section

The core yarn was wrapped by CNT to make it conductive and TPU coating removed the yarn hairiness

DIFFERENT TEXTILE STRUCTURES

a) Integration within Textiles **b) Direct Assembly into Textiles**

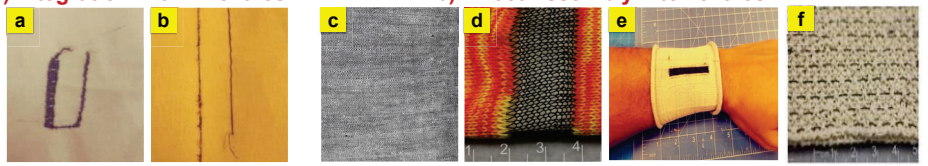

Figure: Different methods of producing CNT wrapped yarn-based smart textiles: a) Embroidering b) sewing c) weaving d) circular knitting e) whole garment knitting f) inlay knit

SMART TEXTILE APPLICATIONS

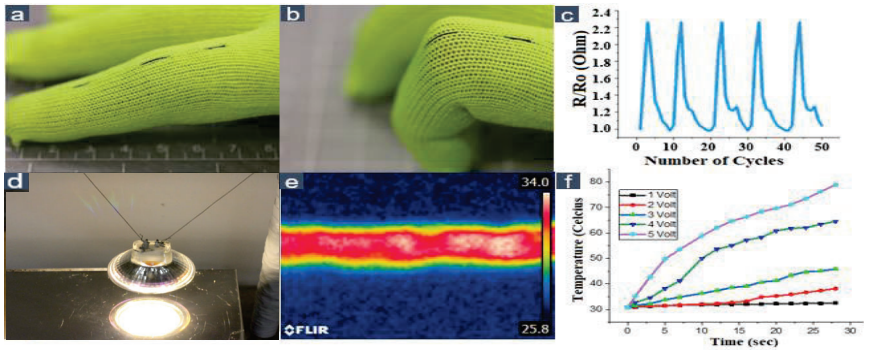

Figure: Smart textile applications a-c) motion sensing d) power transfer e-f) heat generation

Body motion sensing:
- Motion sensing of a single CNT wrapped textile yarn was successfully demonstrated. When the finger was bent, the relative resistance changed rapidly and returned under relaxation of the finger (Fig. a-c)

Power transmission:
- The developed yarn was used for transferring power of 12V (Fig. d)

Heat Generating garments:
- The knitted specimen generated heat quickly and reached skin temperature in less than a minute at 2V showing the potential for low power thermotherapy

CONCLUSIONS

✓Successfully developed a simple production method of electrically conductive CNT wrapped textile yarns which is highly flexible and strong for textile processing

✓The CNT wrapped yarn was successfully integrated into textiles by sewing and embroidering

✓ The yarn was successfully processed into woven and knitted structures for smart textile applications such as body movement tracking, power transmission/interconnects and heating

Next Plan:

✓ Understanding structure-property relationship and their impact on smart textile applications

✓ Modification of the CNTs using nanomaterials to develop dry electrode for wearable electrocardiography and energy storage applications