E-TEXTILES NETWORK WEBINAR

POWERING E-TEXTILES

E-TEXTILES NETWORK: [HTTPS://E-TEXTILES-NETWORK.COM/](https://e-textiles-network.com/)

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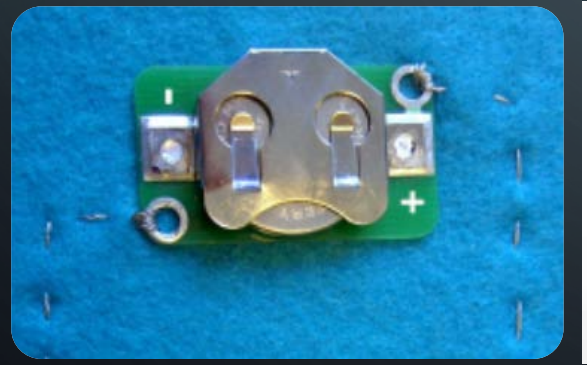
HOW ARE E-TEXTILES CURRENTLY POWERED?

- Existing commercial e-textiles are powered by conventional button cell batteries.
- Rigid batteries are incompatible with the nature and feel of textiles and do not survive washing.
- The development of flexible energy storage and energy generation devices is essential for the next generation of wearable e-textiles.



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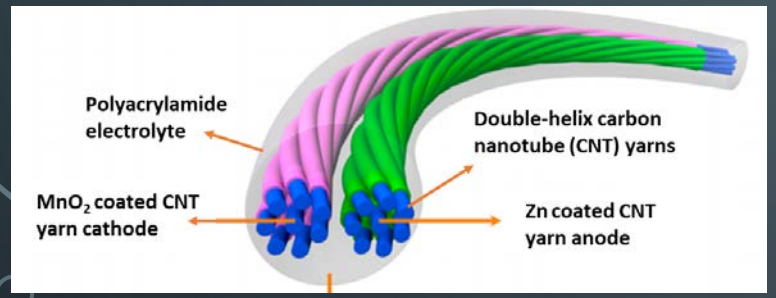
HOW CAN THE INTEGRATION OF BATTERIES WITHIN A TEXTILE BE IMPROVED?

Functionalising Yarns:

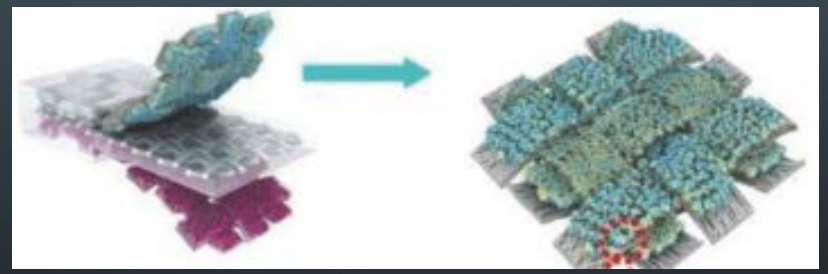


Zinc-Ion class of batteries show good promise. Carbon nano tube yarns coated with MnO_2 and Zn form the anode and cathode of this rechargeable battery yarn.

DOI: 10.1021/acsnano.7b09003.

Functionalising Fabrics:

Zinc-Ion class of batteries show good promise. Textile surface needs to be made conductive and coated with active materials (e.g. MnO_2). https://doi.org/10.1002/smll.201802320



A Textile Lithium Battery uses Cu and Ni coated metallic fabrics as current collectors. Active materials are added to form the cathode and anode and the metallic fabrics, together with separator and electrolyte, are assembled into the battery. DOI: 10.1038/s41467-018-06879-7

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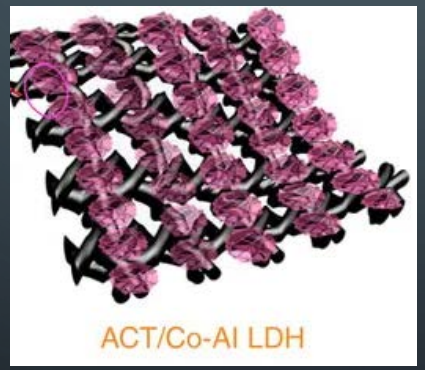
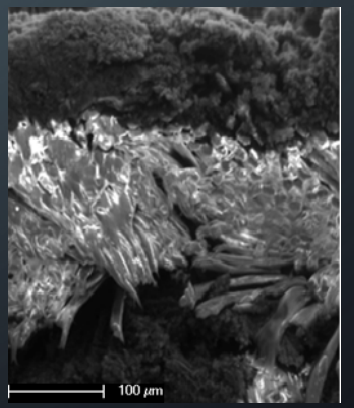
WHAT ARE THE ALTERNATIVES TO TEXTILE BATTERIES?

- Energy can also be stored in textile supercapacitors. These are similar in structure to batteries, possess a lower energy density but are better suited to high power applications and possess much greater cyclical stability.

Supercapacitor yarn (rGO-Ni) https://doi.org/10.1002/adma.201504403



Dip coated cotton textiles form electrodes of a supercapacitor https://doi.org/10.1038/ncomms11586



Supercapacitors can be formed in a single textile by controlling the depth of the electrodes https://doi.org/10.1002/adem.201700860

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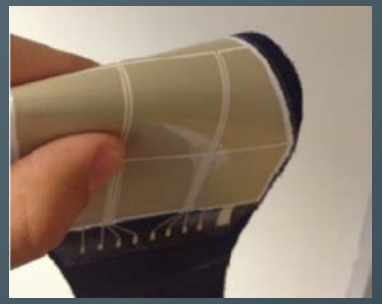
WHAT ARE THE OPTIONS AVAILABLE TO HARVEST ENERGY FROM THE SURROUNDINGS?

- Energy can be converted from a variety of sources into electric energy using a wide range of different mechanisms:
  - Mechanical energy – Piezoelectric/Ferroelectret materials, Triboelectric effect (TENGs)
  - Light – Organic or Dye Sensitised solar cells
  - Thermal energy – Thermoelectric generators
  - Wireless power transfer – RF (rectenna based) or Inductive
- Applying these to textiles and meeting the requirements of the application presents key research challenges.

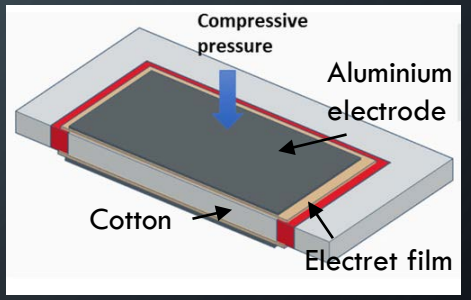
HOW CAN MECHANICAL ENERGY BE HARVESTED?

- Piezoelectric materials can be printed onto textiles – electricity is generated when the textile bends or is compressed
- Textiles can be made into ferroelectrets by laminating with an electret material.
- TENGs work via the generation of static electricity. Combine negative and positive textiles.



Printed composite polymer PZT piezoelectric material https://doi.org/10.1016/j.nanoen.2017.01.037

Ferroelectrets exploit charge trapped at the surface of the electret to form an electrostatic harvester https://doi.org/10.1088/1742-6596/1407/1/012117



Alternating strips of nylon and PVC form a textile TENG. Works by sliding over a textile electrode. https://doi.org/10.1016/j.nanoen.2019.104148

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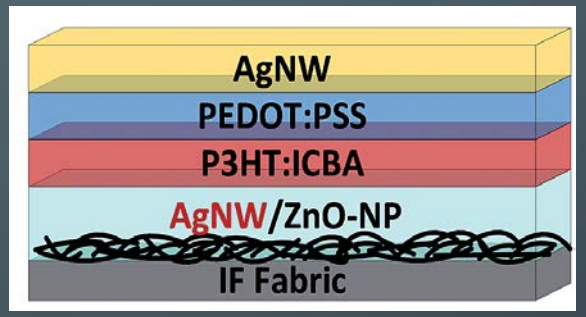
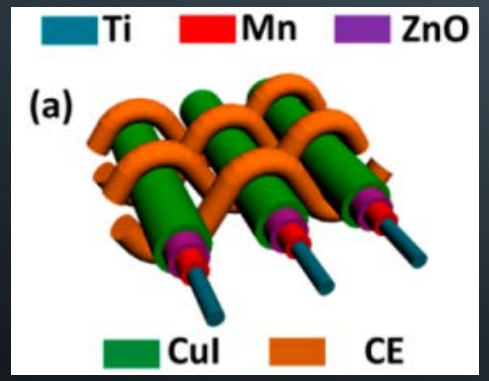
FLEXIBLE SOLAR CELLS EXIST – CAN THESE BE REPLICATED ON FABRICS?

Many examples use flexible solar cells on polymer substrates mounted onto the textile (Midsummer solar roofs)



Spray coated thin film organic solar cells on fabric. https://doi.org/10.1016/j.matpr.2018.02.014

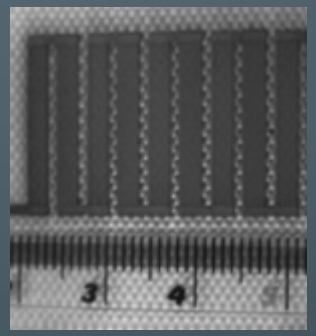


Zinc oxide based dye sensitised solar cell yarns woven with copper coated polymer yarn current collector. https://doi.org/10.1021/acsnano.6b05293

Amorphous silicon photo-voltaic films on woven polyester demonstrated by Power Textiles Ltd. doi:10.3390/proceedings2019032004

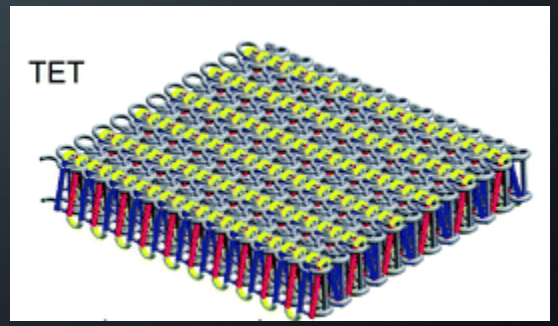
HOW CAN THERMAL ENERGY BE HARVESTED?

Traditional ceramic thermoelectric generators convert heat flow into electrical energy using the Seebeck effect. Flexible thermoelectric textile harvesters have been demonstrated but are very low efficiency and some commonly used materials are toxic.



Screen printed SbTe p-type and BiTe n-type thermoelectric module on glass fibre textile.
DOI: 10.1109/TED.2016.2603071

Carbon nanotube based segmented thermoelectric yarn (TEY) have been used as spacer yarn in a textile.
DOI: 10.1039/C9TA12494B

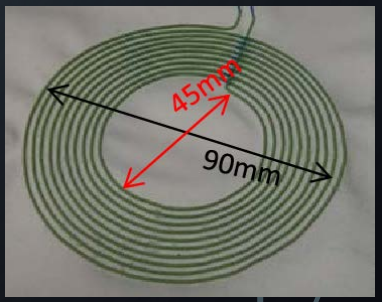


HOW CAN ENERGY BE SUPPLIED WIRELESSLY?

- Energy can be wirelessly transmitted at high frequencies – RF power transfer harvesting ambient RF waves or deliberately broadcast signals
- Lower frequency inductive power transfer can also be used over shorter ranges.
- Both cases require a receiving antenna or coil implemented in the textile.
- The electrical properties of the receiving element and (for RF) the textiles are important considerations.

Textile antenna and rectifier (rectenna) enable RF energy to be captured. Large textile surface area is a positive (DOI: 10.1109/WPTC45513.2019.9055541)

Overstitched multicore Litz wire coils give the best electrical properties (DOI: 10.1109/JSEN.2018.2796138)



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WHAT DO YOU THINK IS THE MOST PROMISING APPROACH FOR INTEGRATING TEXTILE POWER SUPPLIES?

- There is no perfect 'one size fits all' solution – the optimum solution will depend upon the application requirements and energy sources available
- Wireless power transfer can provide a reliable supply of energy under controlled circumstances and this is most likely to be the first practical solution
- Energy harvesting power supplies will typically need some form of energy storage in order to provide an energy reservoir that acts as a buffer.
- Textiles integrated electronics to control the system and manage the flow of energy is also a key requirement.

THANKS FOR LISTENING

- There will be a workshop on the topic of powering e-textiles in 2021
- Also covered at the E-Textiles 2020 virtual conference, 3rd-4th November. See https://e-textilesconference.com/
- Questions from the audience

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