Today’s Agenda

I. Wearable Energy Theory

II. Wearable Energy Technology

III. Wearable Energy Application

IV. Conclusion
Wearable Energy Theory

Planetary model of the atom with nucleus and electrons

Source: Rutherford’s planetary model of the atom

Wearable Energy Theory

Electron size comparison

Proton (+)
Electron (-)
Wearable Energy Theory
Schrödinger’s Cat (Schrödingers Katze)

Wearable Energy Theory
Electric Volt and Ampere

1 Amp (Quantity) → 1 A/h

1 Volt (Power) (+) → (-)

www.cpmt.org/scv
Wearable Energy Technology

Super Capacitor

- Long life span
  - Support million charges
  - Very long life span
- Quick charge/Discharge
  - Quick charge using surface absorption
- Environment Friendly
  - Non-explosive
  - Carbon materials
- High-Capacity/Output
  - Higher than regular capacitor
  - Higher than secondary cell
- Stability
  - Non-explosive

How Super Capacitor Works

CHARGED
- Activated Carbon
- Electrolyte
- Separator

DISCHARGED
Vertically Aligned Graphene Oxide Electrode Film for Supercapacity

Battery Supply Chain

- **Materials**
  - Lead
  - Ni-Cd
  - Lithium ion
  - Lithium Polymer
  - Lithium Metal Hydro

- **Process**
  - Physical cell
    - Solar Cell
  - Chemical Cell
    - Primary
    - Secondary
    - Fuel Cell

- **Form Factor**
  - Cylindrical
  - Pouch
  - Prismatic
  - Thin film

B to B
B to C

Wearable Energy Technology
Basic functionality of Lithium-ion Battery

Wearable Energy Technology
Basic structure of rechargeable battery
Wearable Energy Technology
Basic Battery Type 1

- Cylindrical type
- Prismatic type
- Coin type
- Pouch type

Wearable Energy Technology
Basic form factor of Battery 2

Sealing film
Negative electrolyte
All-solid-state electrolyte
Positive electrolyte
Positive collective electrode
Negative collective electrode
Substrate

Thin Film Battery
3.9V
Wearable Energy Technology
Why Lithium-XXX Battery?

- Highly electropositive (so higher voltage is obtained depending upon the cathode used)
- High electrochemical equivalence
- High capacity (3.82Ah/g) and energy density (1470Wh/Kg)
- Good conducting agent (Good at transport electron)
- Good mechanical stability (low density of lithium metal (0.534g/cc)
- Ease of fabrication/compact design

Why thin and long lasting battery is difficult to make?

**THICK ELECTRODES**
- Anode
- Thin separator, e.g., polymer electrolyte
- Cathode
- High energy density
- Low power density

**THIN ELECTRODES**
- Low energy density
- High power density
Wearable Energy Technology
EV drive range and EV battery weight

Vehicle Test Mass (kg)

Lead Acid Battery EV
NiMH Battery EV
Li-Ion Battery EV
Fuel Cell EV

300 miles (500km)


Wearable Energy Technology
Interconnected hollow carbon nanospheres for stable Li metal anodes

SEI: Solid electrolyte interface

Wearable Energy Technology
Is Graphene ultimate materials for battery?

Graphite
Acid solution
Oxidant
Preprocessing
Continuous Oxide Graphene reactor

Source: http://English.etnews.com/device/2956730_1304.html

Wearable Energy Technology
Is Graphene able to be mass-produced?
Sources of Energy Harvesting

- Electrochemical Reaction
- Water flow
- Wind Compressed Gasses
- Thermal Reservoir
- Autophagous Structure battery

Energy Harvesting devices

- DC/AC Generator
- Piezoelectric Transducer
- Capacitive Transducer
- Induction Coil & magnet
- Antenna / Rectenna
- Photovoltaic Cell
- Induction Coil
- Antenna / Rectenna

Energy Harvesting Devices

- Mechanical Vibration
- Artificial lighting
- Power Transmission lines
- Microwave radiation
- Solar Radiation
- Radio waves

Source: http://wonderfulengineering.com/german-engineer-makes-a-free-energy-harvesting-device/
Wearable Energy Technology
Kinetic Energy Harvesting

Wearable Energy Technology
Thermal Energy Harvesting
Wearable Energy Technology
Rectenna Energy Harvesting

Wearable Energy Application: Super-capacity
Hybrid Energy Storage system with Fuel Cell, Battery & Supercapacitor
Wearable Energy Application: Super-capacity
Flexible pouch type battery and Roll to Roll battery cloth

Source: http://www.flexelinc.com/products.html

Wearable Energy Application: Energy Harvesting
Vibrating sports shoes powered by piezoelectric power generator

Vibration chip called IMOOV chip is powered by piezoelectric generator.
Wearable Energy Application: Energy Harvesting

Intelligent Thermostatic Radiator Valve using Thermoelectric Energy Harvesting

Wireless Thermostatic Radiator valve working With intelligent home thermostats

Wearable Energy Application: Energy Harvesting

Wireless charging system using Rectenna Energy Harvesting

Source: humavox

Source: Ossia
Wearable Energy Application: Energy Harvesting

Solar Bikini Smart phone battery charger

Source: http://www.actnergroup.com/wearable/wearable-clothing-device/

Conclusion

Economy of scale is very important to any wearable energy source

Source: Gelon LIB Group
Conclusion

Both S/W and H/W need to be optimized to support longer battery life span

Conclusion

Scientists need to focus more on their research not on some PR stuff
Conclusion

New break through technology is urgently required.

Questions?

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