Wearable Energy Sources
- Materials perspective

Materials and System
Incorporated
a materials company

For IEEE Wearable Technology
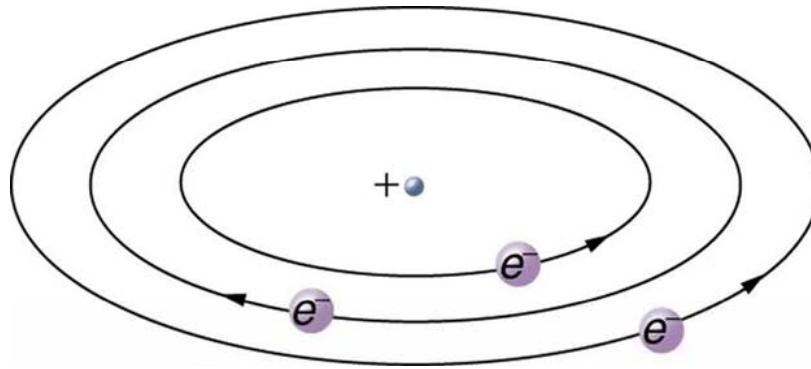- Seminar and Tabletop Exposition

Today's Agenda

I. Wearable Energy Theory

II. Wearable Energy Technology

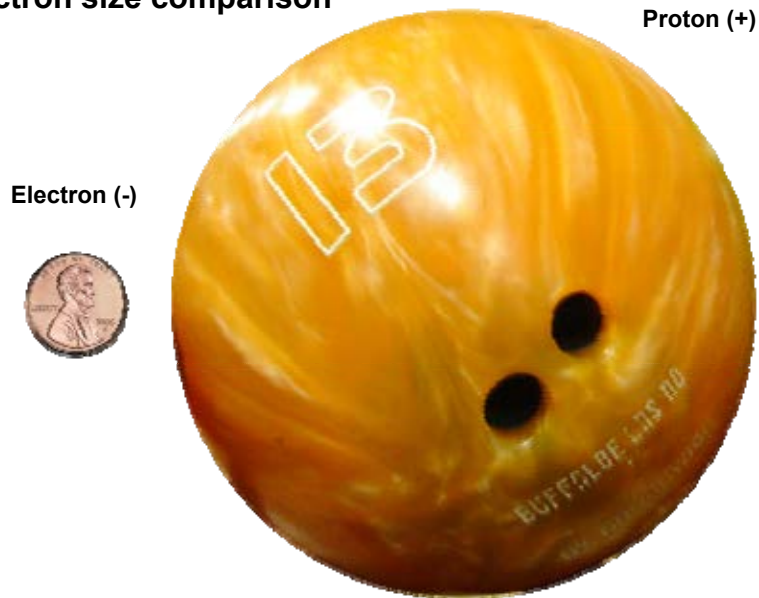**III. Wearable Energy Application**

IV. Conclusion

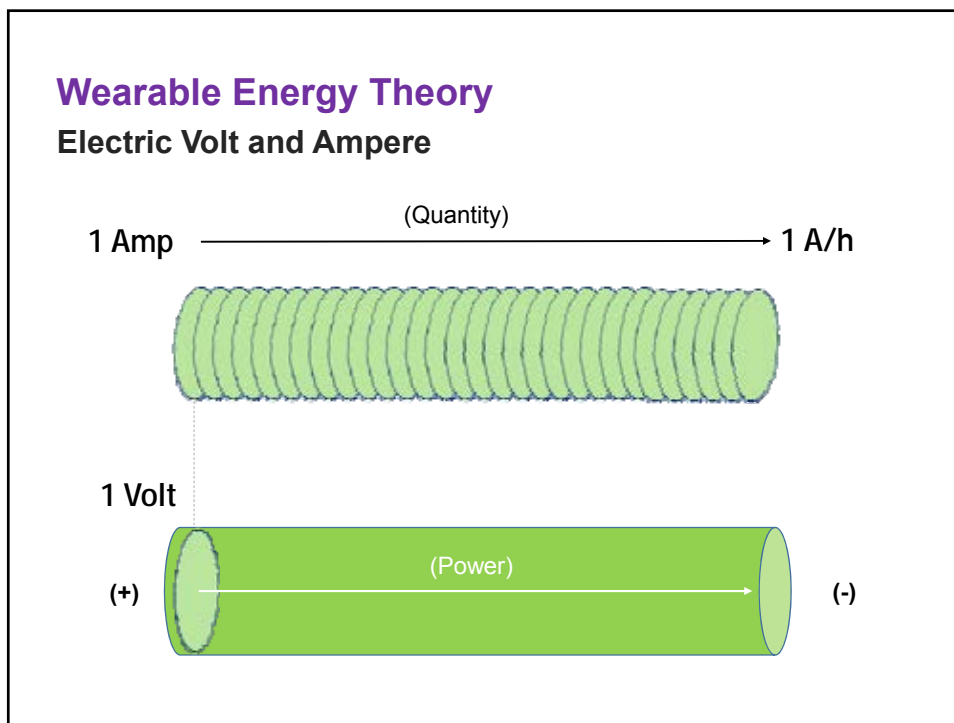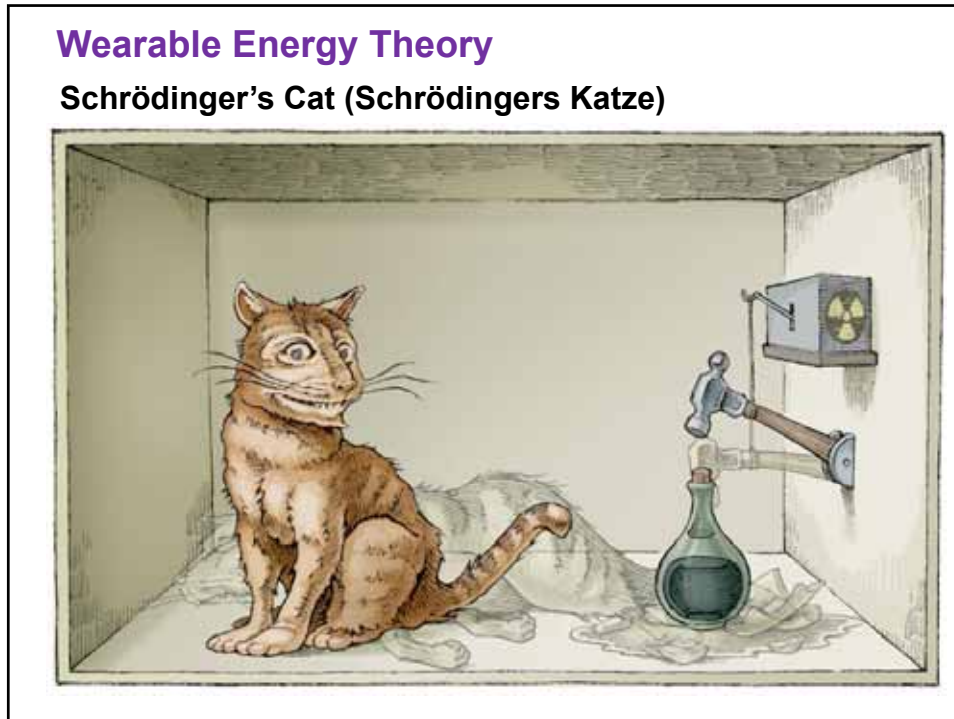## Wearable Energy Theory
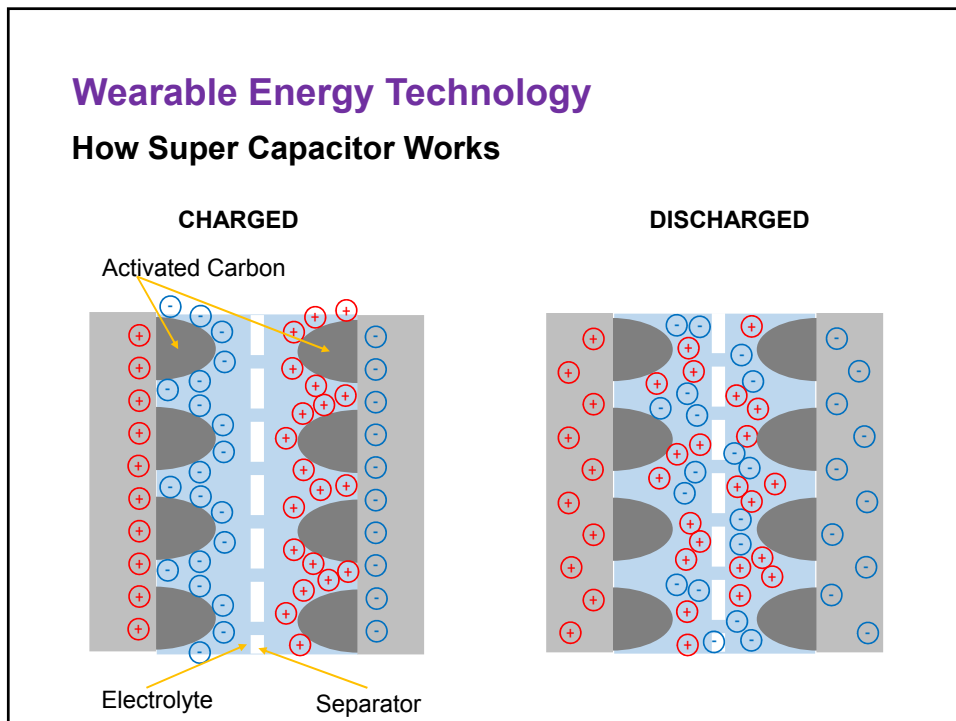
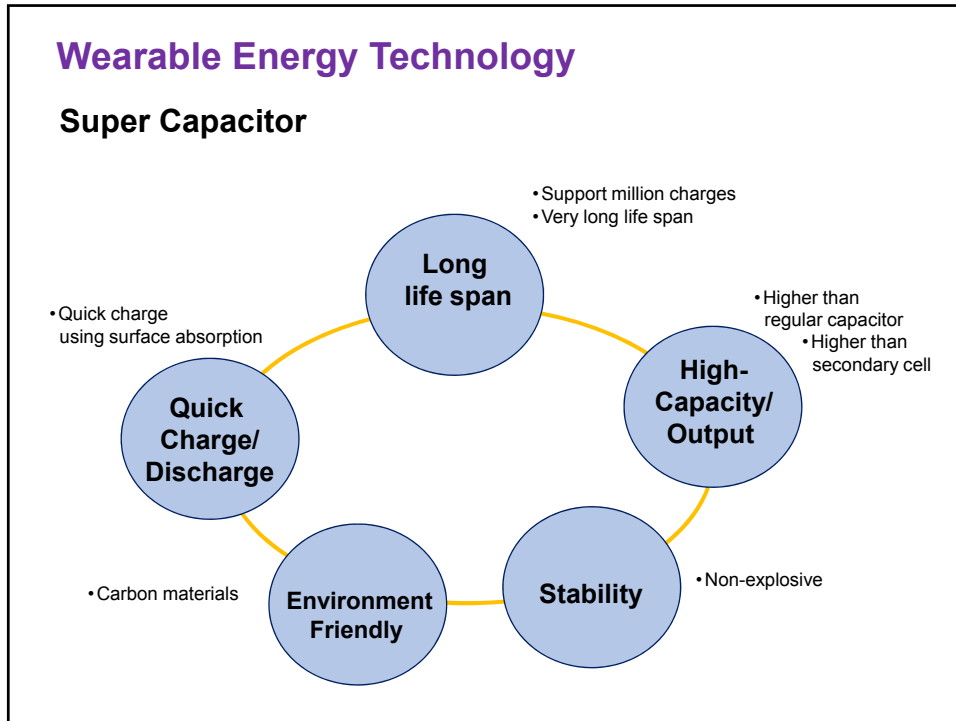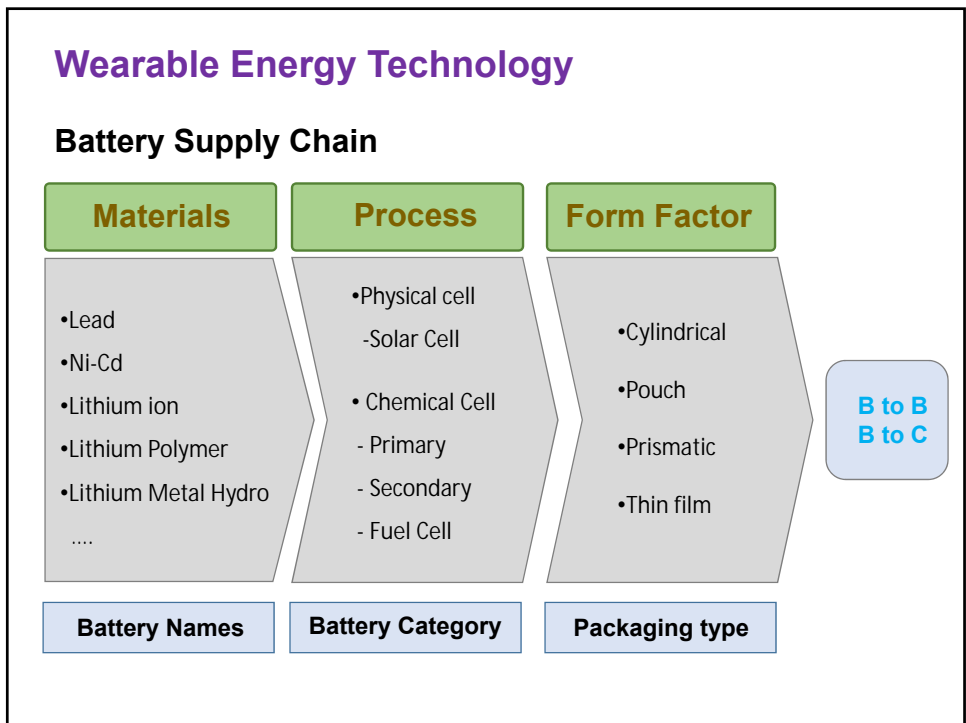**Planetary model of the atom with nucleus and electrons**
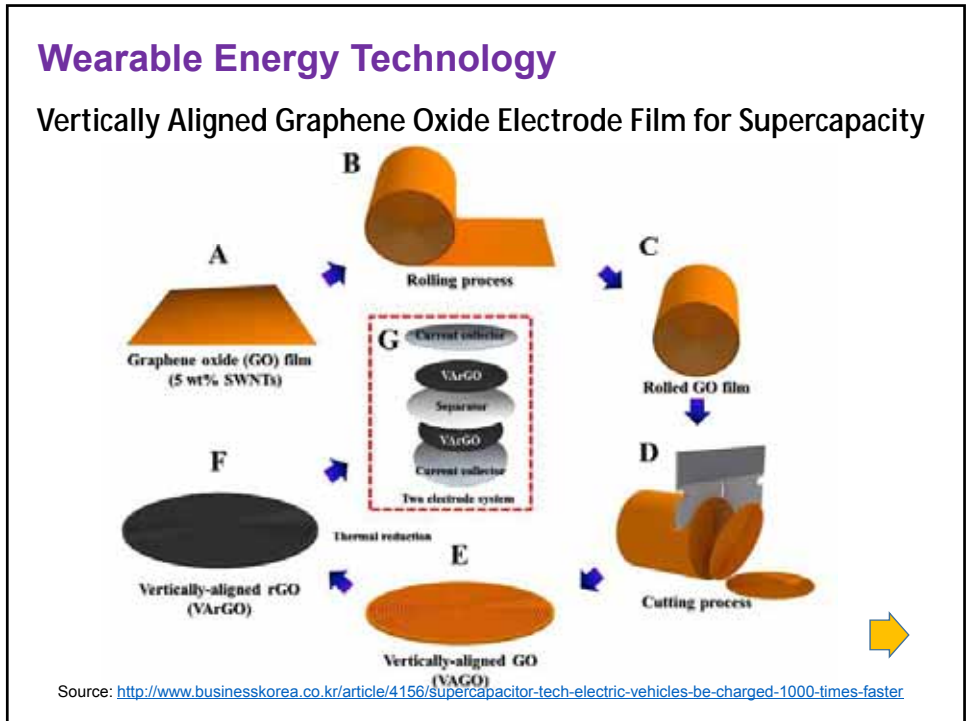

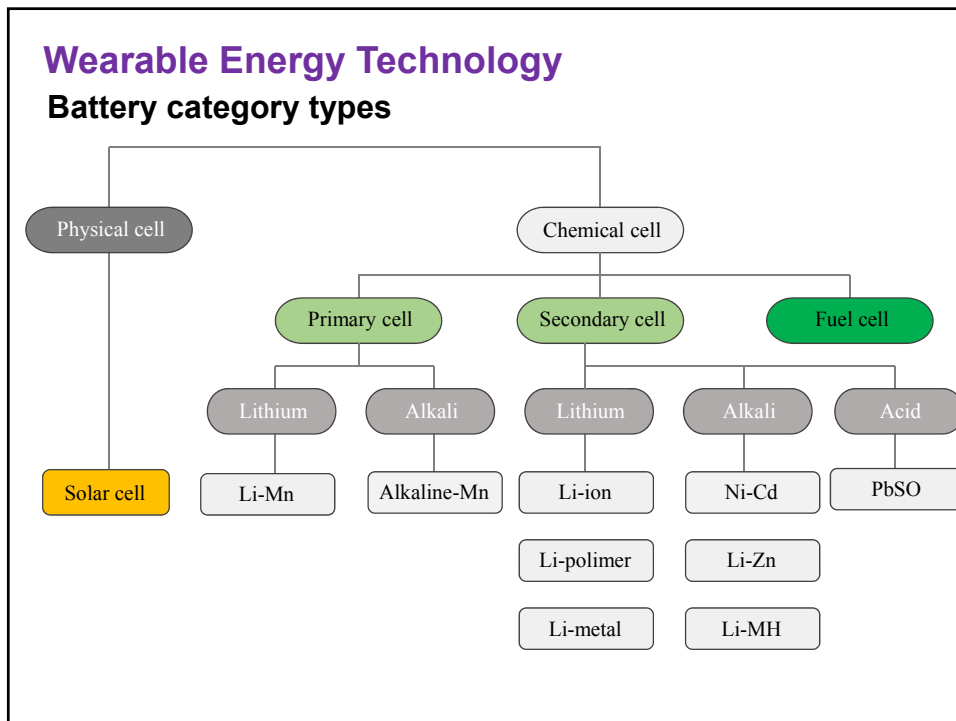**Source:** Rutherford's planetary model of the atom

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)   (-)

Wearable Energy Technology

Super Capacitor

- Support million charges
- Very long life span

Long life span

High-Capacity/Output

- Higher than regular capacitor
- Higher than secondary cell

- Quick charge using surface absorption

Quick Charge/Discharge

Stability

- Non-explosive

- Carbon materials

Environment Friendly

Wearable Energy Technology

How Super Capacitor Works

CHARGED

DISCHARGED

Activated Carbon

Electrolyte   Separator

Wearable Energy Technology

Vertically Aligned Graphene Oxide Electrode Film for Supercapacity

Source: http://www.businesskorea.co.kr/article/4156/supercapacitor-tech-electric-vehicles-be-charged-1000-times-faster

Wearable Energy Technology

Battery Supply Chain

Materials	Process	Form Factor
•Lead •Ni-Cd •Lithium ion •Lithium Polymer •Lithium Metal Hydro	•Physical cell -Solar Cell • Chemical Cell - Primary - Secondary - Fuel Cell	•Cylindrical •Pouch •Prismatic •Thin film
Battery Names	**Battery Category**	**Packaging type**

B to B
B to C

Wearable Energy Technology
Battery Production Process
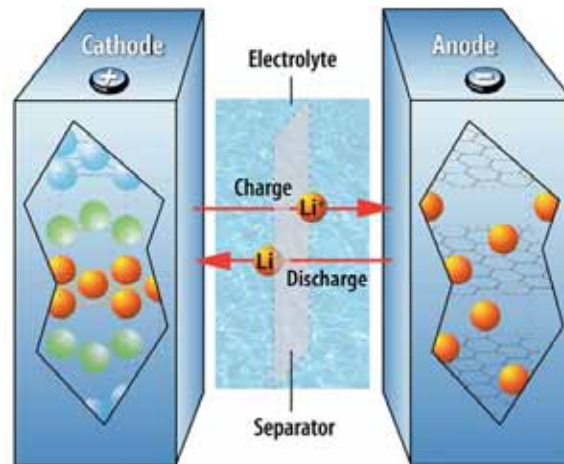
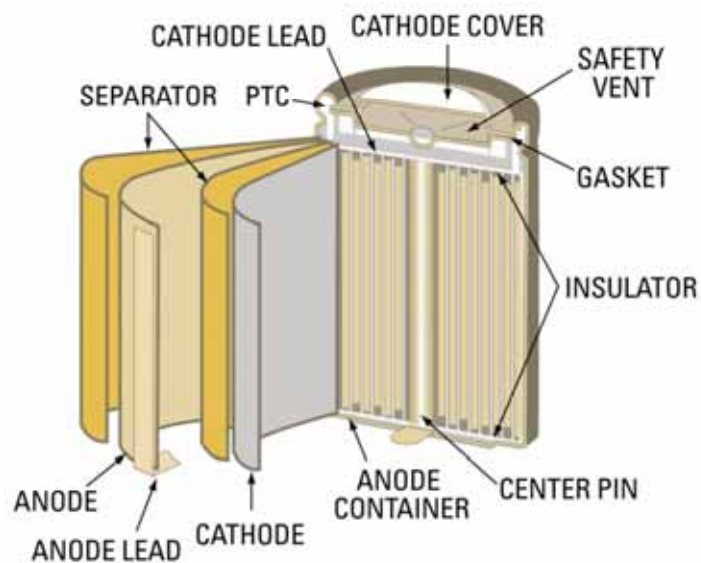

Wearable Energy Technology
Battery category types

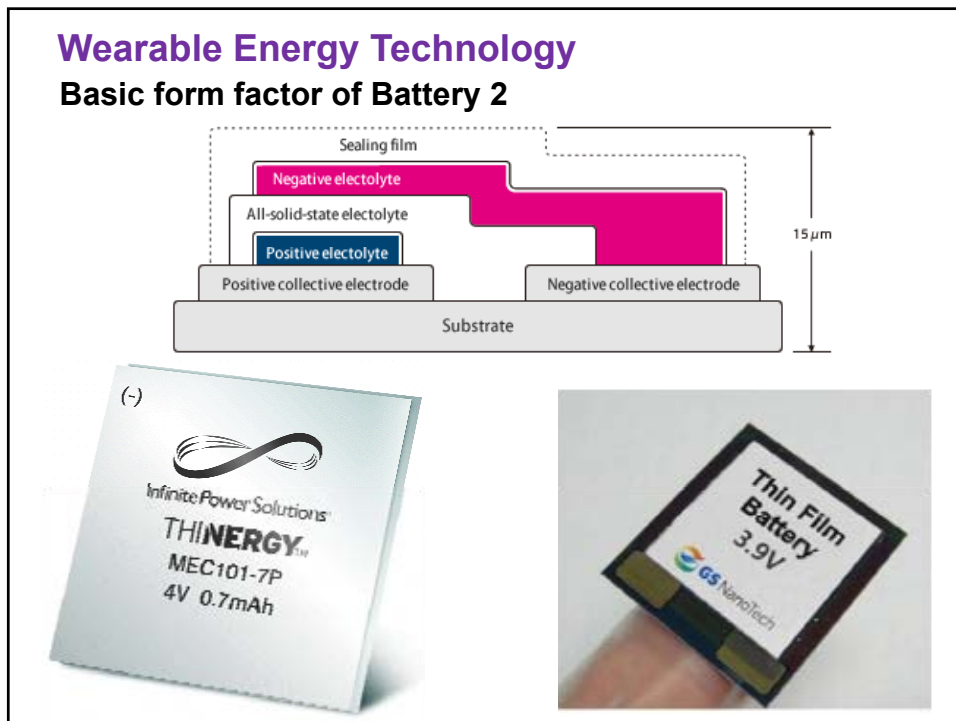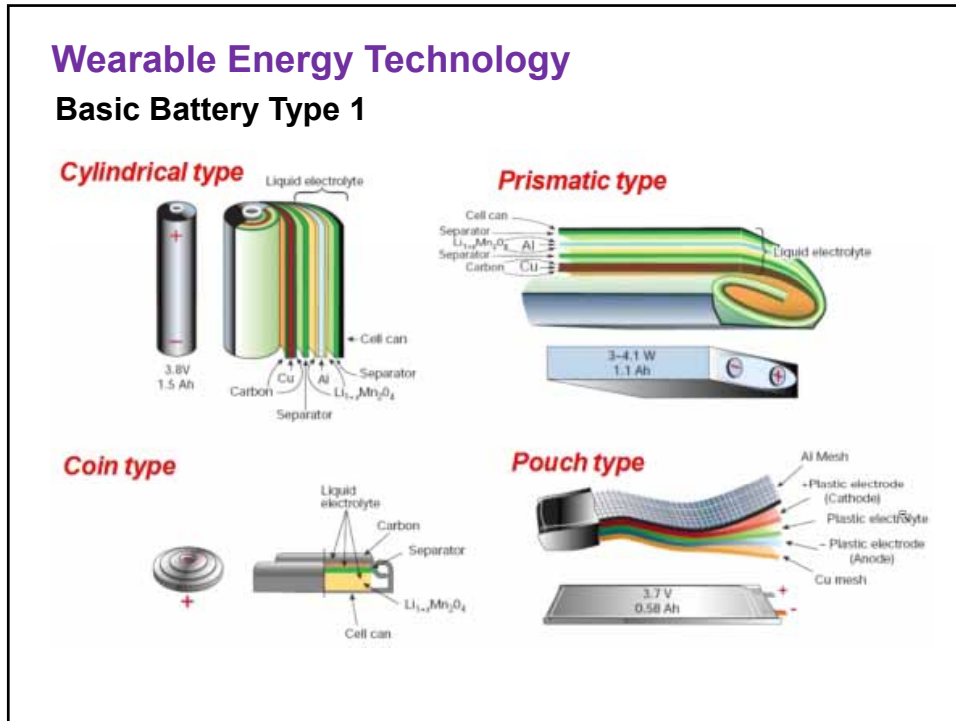## Wearable Energy Technology
Basic functionality of Lithium-ion Battery

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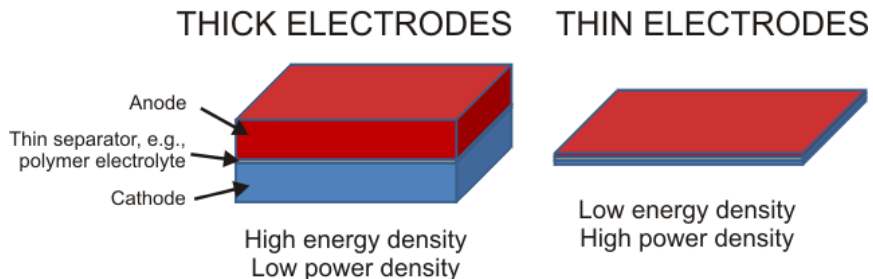
Wearable Energy Technology
Basic Battery Type 1

Wearable Energy Technology
Basic form factor of Battery 2

Wearable Energy Technology

Why Lithium-XXX Battery?
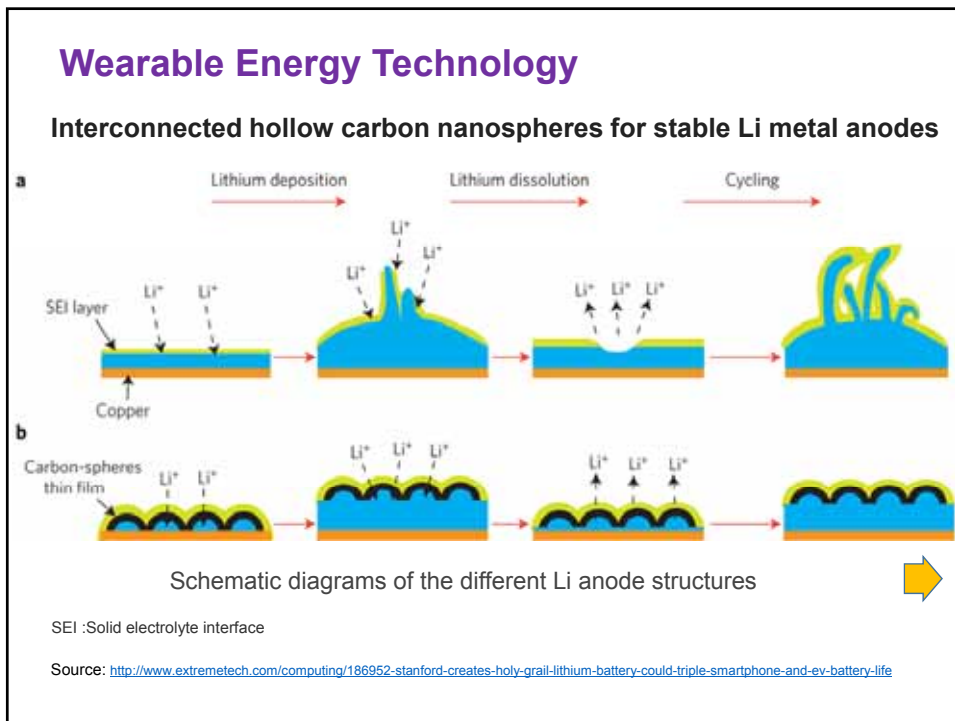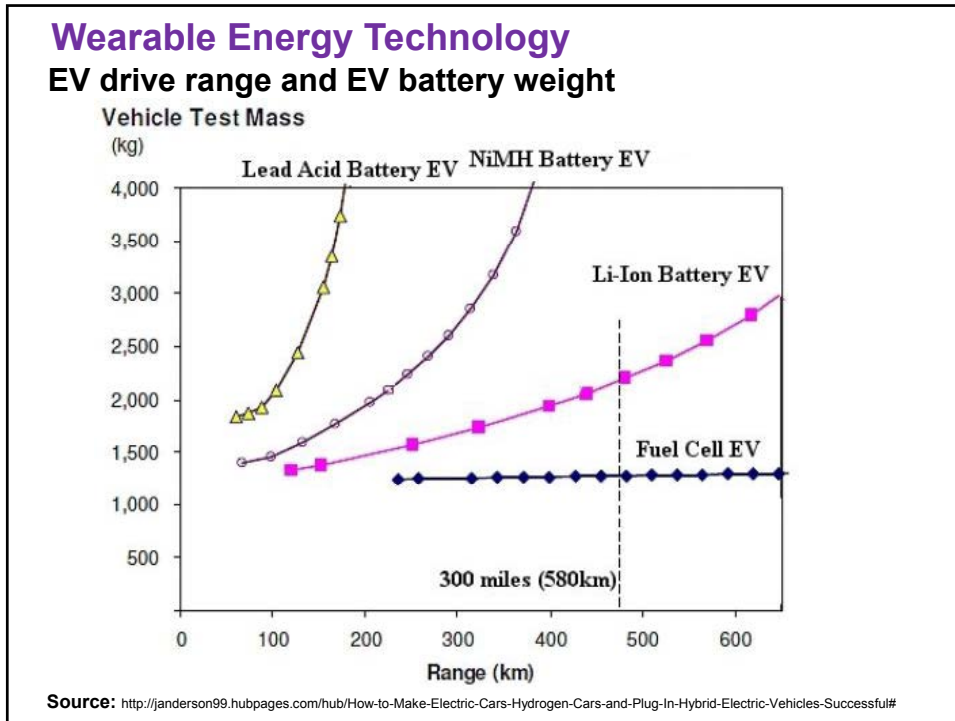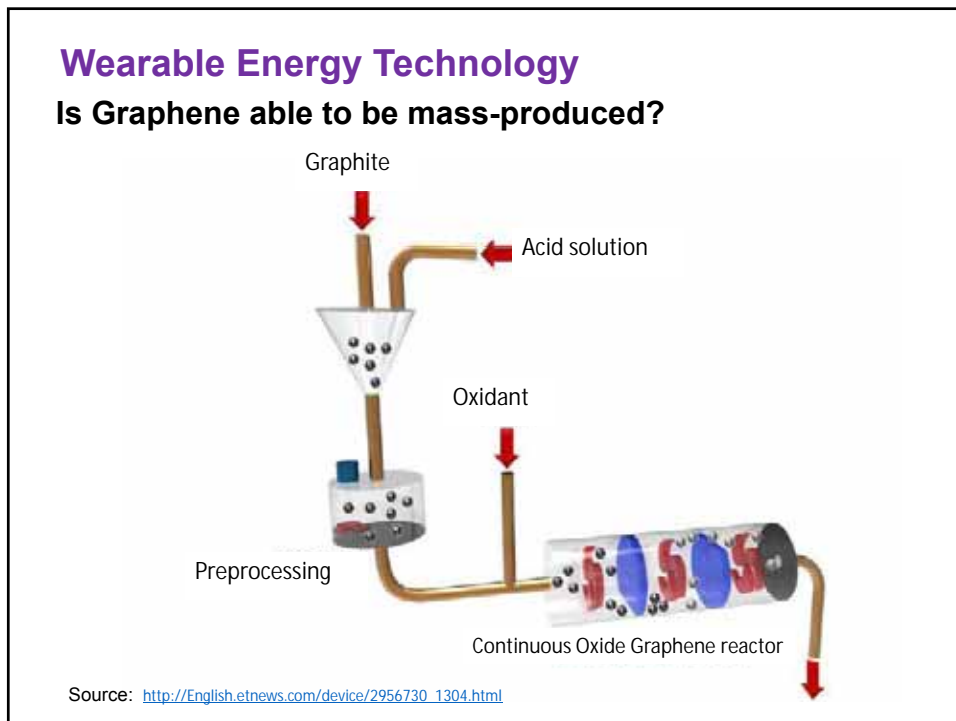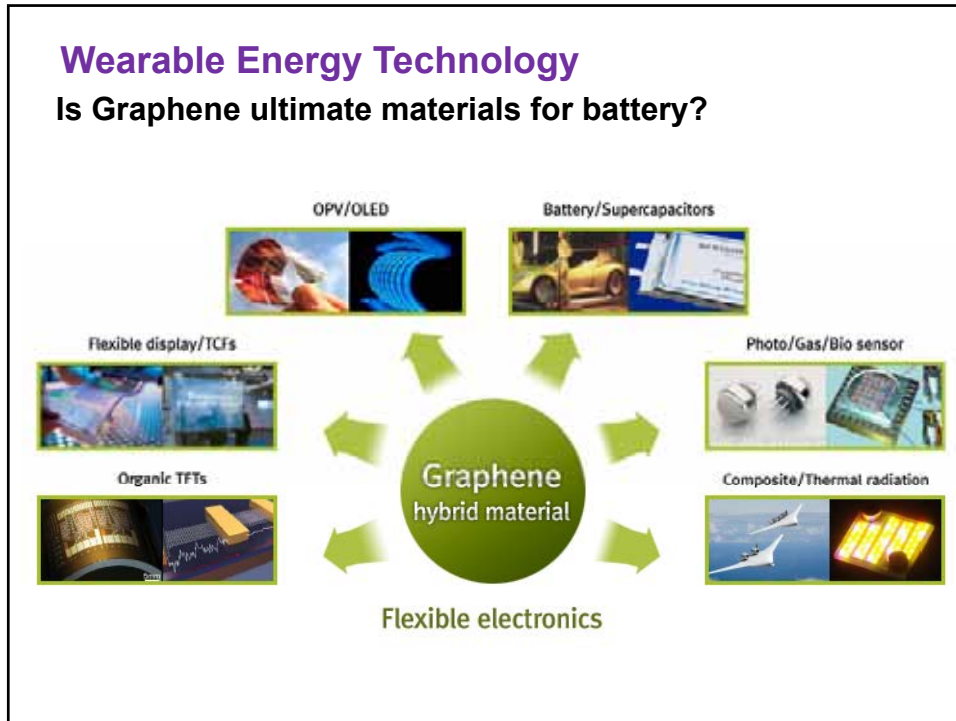
Periodic Table of the Elements

- 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)
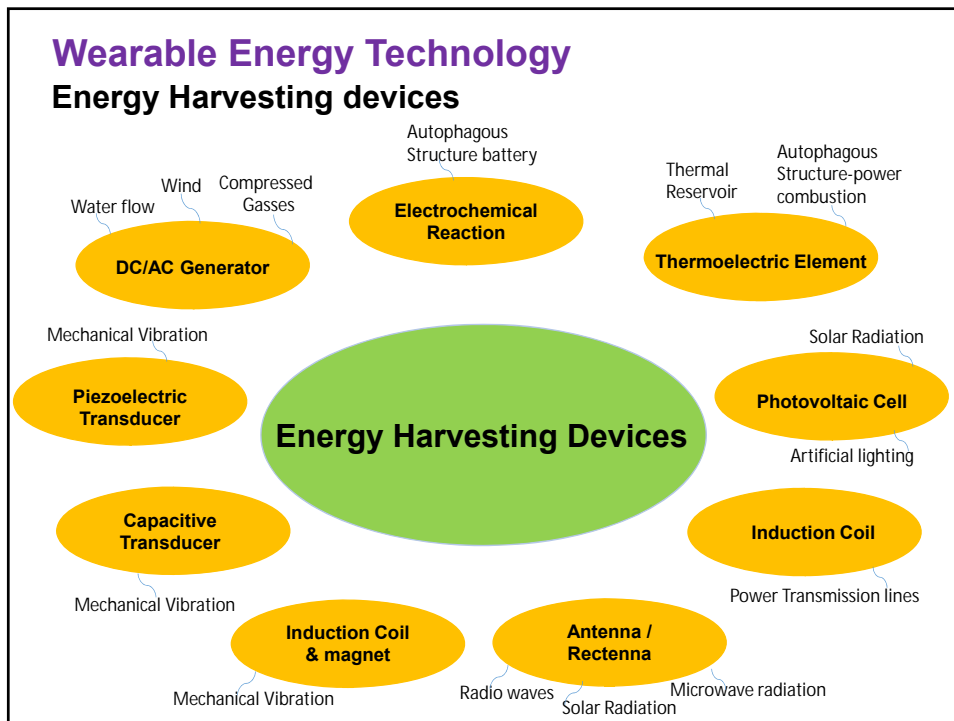- Ease of fabrication/compact design

Wearable Energy Technology
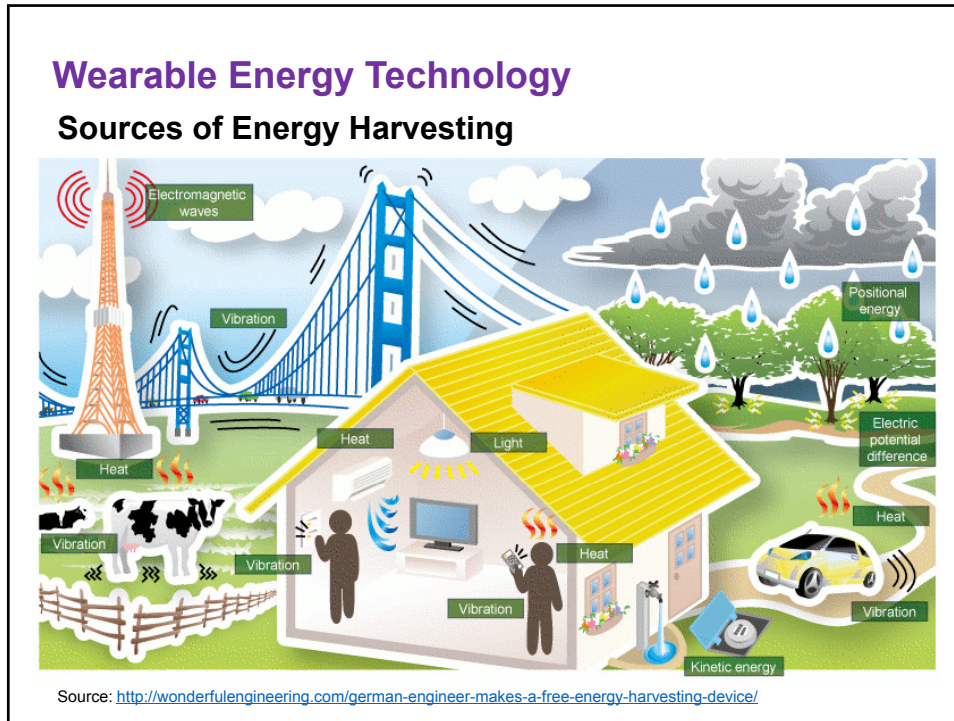
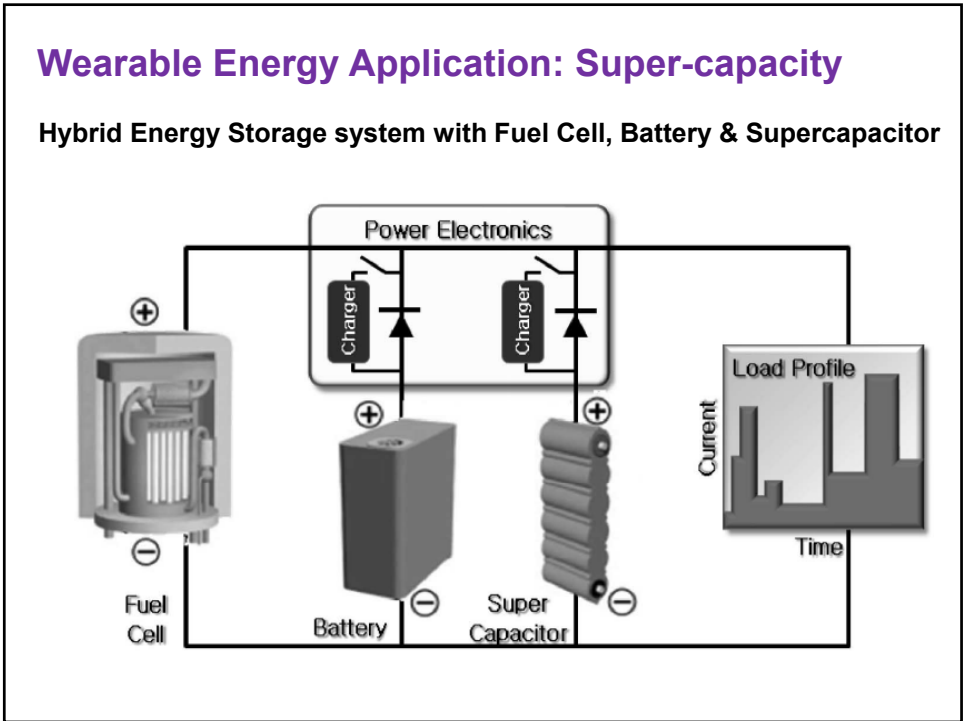### Why thin and long lasting battery is difficult to make?

THICK ELECTRODES   THIN ELECTRODES

Anode
Thin separator, e.g., polymer electrolyte
Cathode

High energy density
Low power density

Low energy density
High power density

Wearable Energy Technology
EV drive range and EV battery weight

Source: http://janderson99.hubpages.com/hub/How-to-Make-Electric-Cars-Hydrogen-Cars-and-Plug-In-Hybrid-Electric-Vehicles-Successful#

Wearable Energy Technology

Interconnected hollow carbon nanospheres for stable Li metal anodes

Schematic diagrams of the different Li anode structures

SEI :Solid electrolyte interface

Source: http://www.extremetech.com/computing/186952-stanford-creates-holy-grail-lithium-battery-could-triple-smartphone-and-ev-battery-life

Wearable Energy Technology
Is Graphene ultimate materials for battery?

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

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

Wearable Energy Technology
Sources of Energy Harvesting

Source: http://wonderfulengineering.com/german-engineer-makes-a-free-energy-harvesting-device/

Wearable Energy Technology
Energy Harvesting devices

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
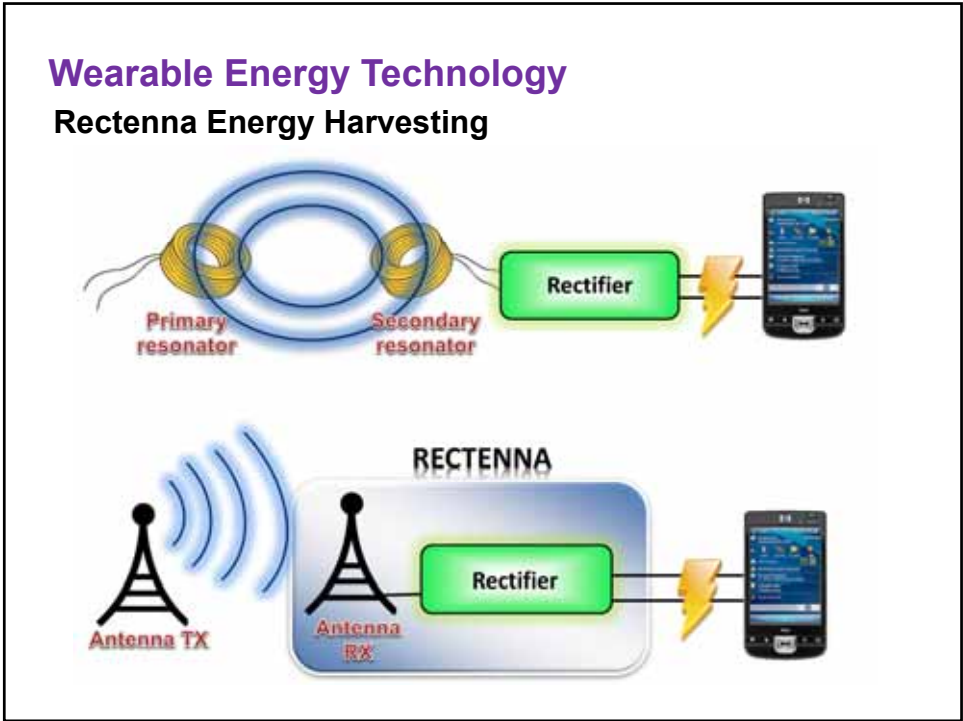
Wearable Energy Application: Super-capacity

Flexible pouch type battery and Roll to Roll battery cloth

Source : http://www.flexelinc.com/products.html
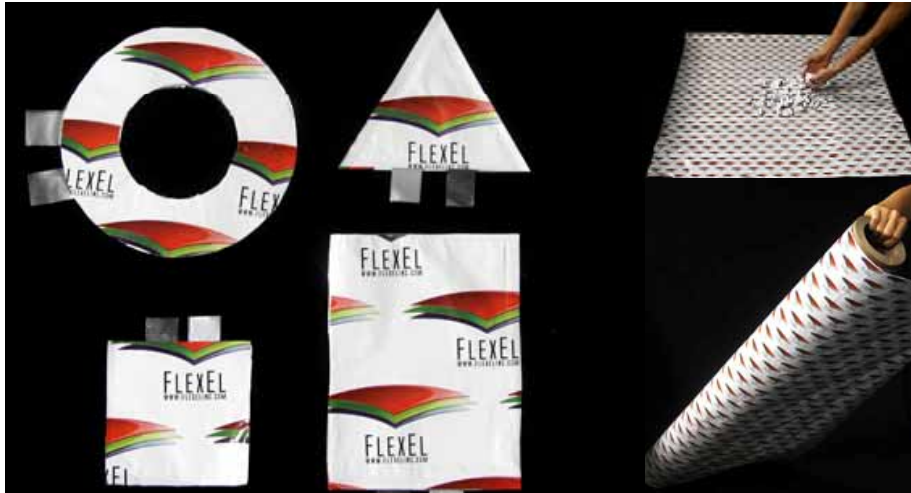
Wearable Energy Application: Energy Harvesting

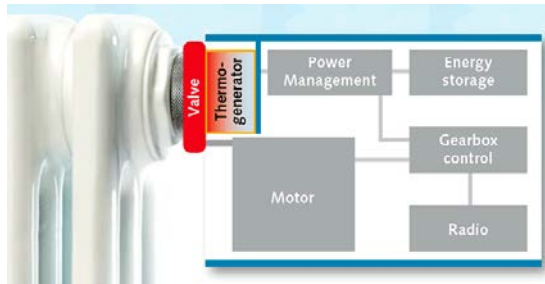**Vibrating sports shoes powered by piezoelectric power generator**

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

Pressing line（auto）

Electronic production line（auto）

Winding line（auto）

Winding line（auto）

Laser welding line（auto）

Grading line

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.

Source: http://venturebeat.com/2013/11/06/samsungs-promises-devices-with-foldable-displays-by-2015-tries-to-make-fonblet-a-thing/

Questions?

**Materials and System
Incorporated**
a materials company

**3003 N. 1st Street, Suite 221
San Jose, CA 95134, USA**

**Tel: 408-519-2267
eMail: jayhah7@gmail.com
Skype: jayhah7**