Wisconsin State Telephone Cooperative Association

Technologies and the Future

Finley Engineering Company, Inc.
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ENGINEERING

INNOVATION TO THE NEXT POWER

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Agenda

- Technology and its impact on the Society
  - Introduction
    - Good Old Days
    - Inventors
  - Hardware
    - Memory
    - Chips
  - Fun Stuff
  - How we Interact
  - Where are we going

Imagine If…..

Introduction

- When was the term : "Remember the Good Old Days" coined?
  - In 1840 when this term was coined, a your grandparent could understand your world
  - By the next generation, it is expected that your parents will not be able to understand your world

Introduction

- How much??
  - 56 kilobytes: Significant data amount in 1970's
  - 1 Megabyte: Universal measure in 1990's
  - 1 Gigabyte: 1,000 Megabytes Universal measure by 2004
  - 1 Terabyte: 1,000 Gigabytes by 2009
    - Monthly mobile traffic expected to reach 500,000 Terabytes by 2011
    - The traffic will double in each of the next two years
  - 1 Petabyte: 1,000 Terabytes
  - 1 Exabytes: 1,000 Petabytes (10 followed by 18 0s)
    - Projected monthly mobile data traffic by 2013
    - 64% of the traffic will be video
    - Half of all of the data traffic generated in 1999

Introduction

A vision without the technology to implement it is science fiction.

Introduction

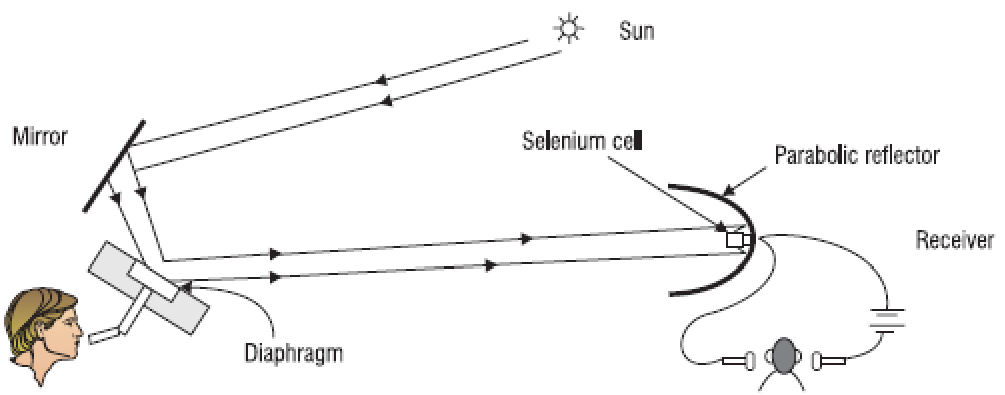

Figure 7-2 *Schematic of the photophone invented by Bell. In this system, sunlight was modulated by a vibrating diaphragm and transmitted through a distance of about 200 meters in air to a receiver containing a selenium cell connected to the earphone.*

"I have heard a ray of light laugh and sing. We may talk by light to any visible distance without any conducting wire." Alexander Grahm Bell in a letter to his father in 1880

"Optical Waveguides and Fibers", Module 1.7 Ajoy Ghatak and K. Thyagarajan, Department of Physics, Indian Institute of Technology, New Delhi, India

Introduction

- Charles Kao:
  - 2009 Nobel Prize Winner for Physics
  - In 1966 discovered the impurities in glass that were hindering long distance fiber optic communications
  - The breakthrough allowed an ultra pure glass fiber in 1970
- Willard Boyle and George Smith
  - 2009 Nobel Prize Winner for Physics
  - Created the first successful image using a digital sensor in 1969
  - It is believed that data derived from the Charge-Coupled-Device now comprises the bulk of data transmitted today

Introduction

- 2010 Nobel Prize for Physics
  - Professor Andre Geim, left
  - Konstantin Novoselov, right
  - University of Manchester
  - 2004 Demonstrated the ability to create a single layer of Graphene
    - Amazing what you can do with Scotch Tape

Associated Press Photo
http://news.yahoo.com/s/ap/20101005/ap_on_hi_te/eu_nobel_physics

Hardware

- Memory
- Chip Design
- Applications
  - Using hand held devices
  - Planes
  - Cars
  - Vision

Hardware: Revolution in Memory

- Memory
  - RAM Family (DRAM, SDRAM, etc.): Main Memory used in today's Computers
    - Fast
    - Low Power
    - Practical up to 8G
    - Volatile
    - May require a refresh to maintain data
    - Scaling reached in 3 years using existing technology
  - Flash: Boot Memory for computers, memory cards/sticks, notebooks
    - Low Power
    - Nonvolatile (retains contents with power shut off)
    - Practical up to 16GB, can reach 128GB
    - Slower than RAM
    - Wear out over time

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Hardware: Revolution in Memory

- Memory
  - Hard Disk: Primary mass storage devices
    - Highest storage capacity over 2TB
    - Lowest cost per Byte
    - Nonvolatile
    - Getting faster
    - Requires exotic configurations to boost speed and reliability
    - Moving parts
    - Can fail unexpectedly

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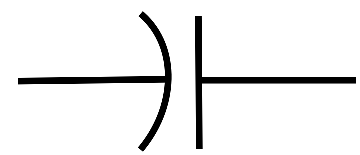
Hardware: Revolution in Memory

- All electronic devices are comprised the following fundamental passive devices
  - Capacitor: A device containing two conductors separated by an insulator that will store a charge when a potential is applied across the conductors.



1745 vonKleist, Musschenbroek, Benjamin Franklin
$Q=CV$ $dQ=CdV$ Unit of Measure: Farad f

Hardware: Revolution in Memory

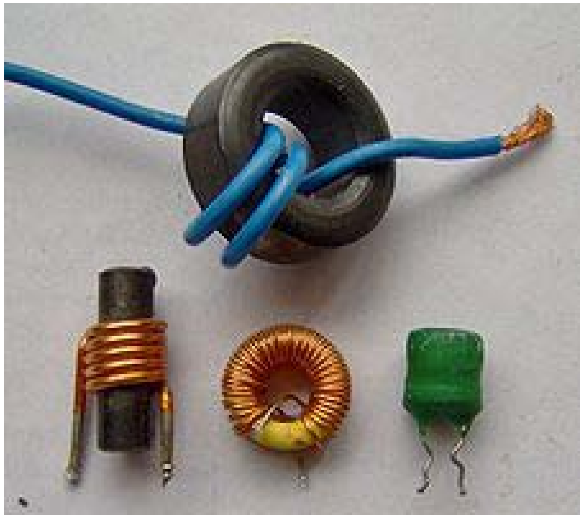
- Resistor: A device that develops a voltage in direct proportion to the current flow through it the device.

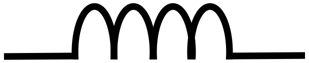
1827 George Ohm V=RI dV=RdI

Unit of Measure: Ohms Ω

Hardware: Revolution in Memory

- Inductor: A device that stores energy in a magnetic field as a result of the current that passes through the device.

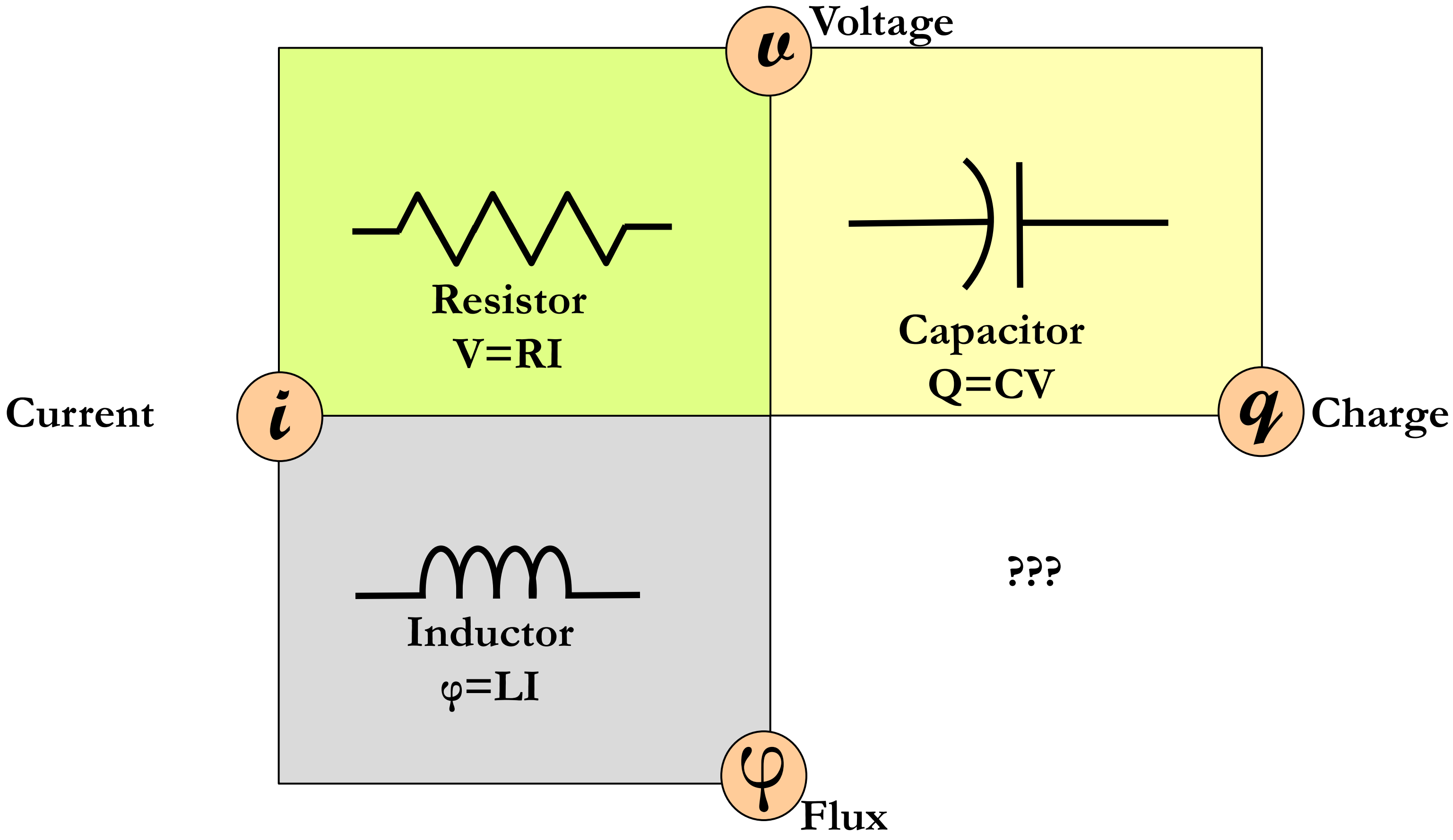




1831 Michael Faraday & Joseph Henry

φ=LI d φ=LdI Unit of Measure: Henry φ

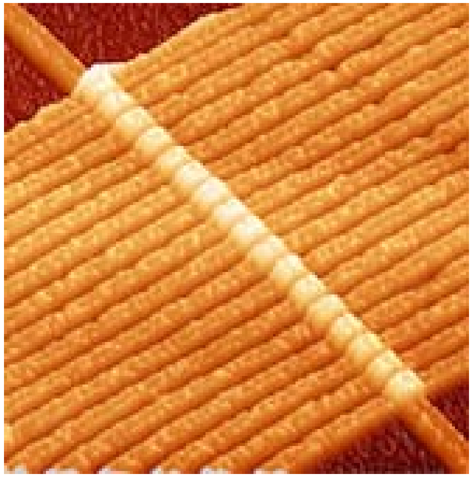
Hardware: Revolution in Memory



Hardware: Revolution in Memory

- Leon Chua
  - Considered the Albert Einstein of non linear circuit theory
  - Created a mathematical model of the memristor in 1971; however, was unable to create a working example
- Hewlet Packard
  - 2008 successfully created the memristor on a chip
  - Simple CMOS support system
  - Created an addressing scheme that will allow up to 1000 layers

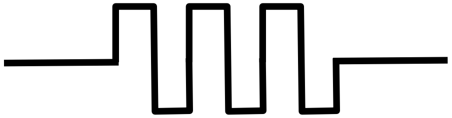
http://www.youtube.com/watch?v=bKGhvKyjgLY&feature=player_embedded#!



http://en.wikipedia.org/wiki/Memristor

Hardware: Revolution in Memory

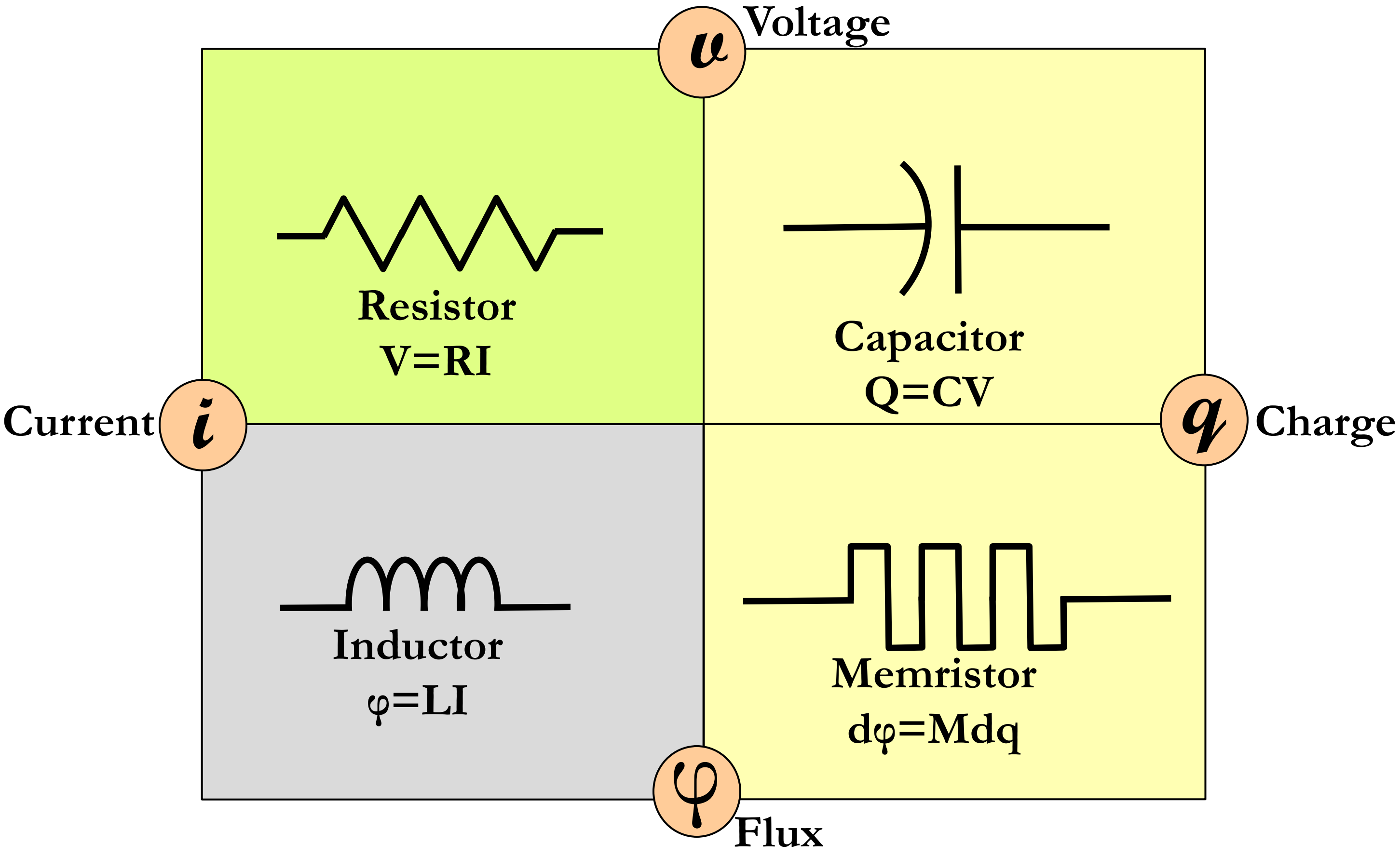
- Memristor: The fourth two node static electrical device (Capacitor, Resistor, Inductor)
  - A resistor that has a memory of the previous voltage and current. The device is based on the relationship between flux and charge.



1971 Leon Chua

dφ=Mdq State Variable: w

Hardware: Revolution in Memory



Hardware: Revolution in Memory

- Memory
  - Memristor:
    - Nonvolatile
    - Very low power
    - Extremely high density – 1 Peta Byte per cm^2
    - Simple Addressing Scheme
    - Does not need refreshing
    - Can support neural logic

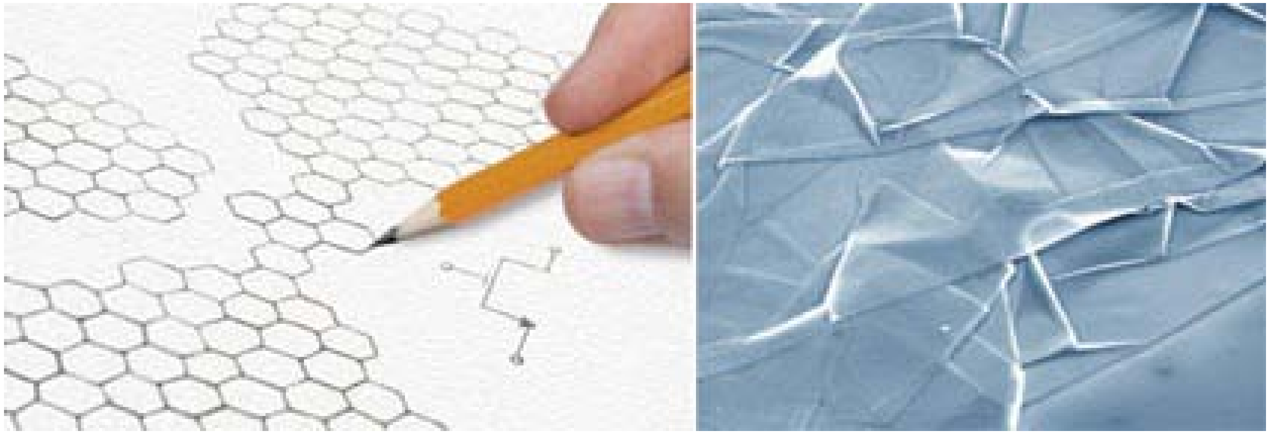
Hardware: Revolution in Memory

- Memory
  - What is possible with the Memristor?
    - Replacement for the RAM, Flash, Hard Drive, CD, DVD
    - Processing and tremendous data storage on the same device
      - Eliminates chips and infrastructure to support them
      - Reduces power consumption, extended battery life
      - Entire data, music, and video library on a handheld device
      - The handheld device may become your main computer
    - RAM Clouds – J. Ousterhout et.al. Sanford
      - Ultralow Latency
        - No moving Parts
        - Minimal Bus Requirements
      - Ultralow Power Requirements
      - Smaller
      - More Reliable

Hardware: 32 nm Technology

- Allows transistors at approximately ½ the size of the current 45 nm transistors
- 1.9 billion transistors on the same Integrated Circuit Chip

Hardware: Graphene



- Graphene:
  - Theorized as early as 1947
  - Single layer discovered in 2004 by Kostya Novoselov at the University of Manchester
  - Form of pure Carbon found in graphite (pencil lead)

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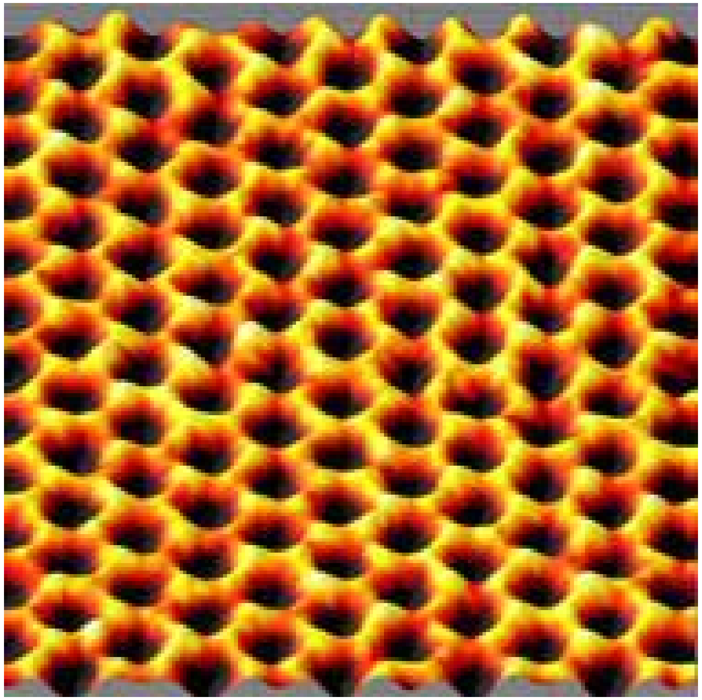
Hardware: Graphene

- Physical Properties:
  - 200 times stronger breaking strength than steel
  - Virtually invisible at a single layer thick
  - Highly conductive electrically, significantly more than silver
  - Highly conductive of heat, equaling diamond
  - High melting point



Picture from GrapheneEnergy.net

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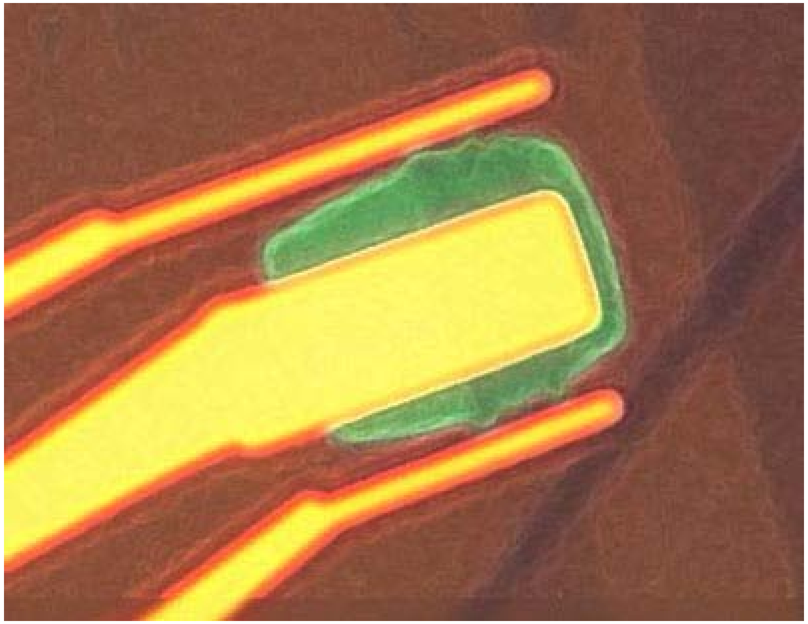
Hardware: Graphene Transistors

- Physical Properties:
  - Recent developments now make it relatively easily to form into crystal structures 1 atom thick
    - Capable of extremely strong membranes for sensors, yet low enough mass to not distort the results
  - Has the highest surface area per gram of any other molecule
    - Ideally suited for bio-medical or substance detection

Hardware: Graphene Transistors

- Graphene Transistors:
  - Pioneered by Dr. Walter de Heer
  - World's smallest transistor p type 1 atom by 50 atoms developed in 2008
  - N-type transistor developed in May of 2009
  - Potential of 1 nm transistor technology
  - Electrons in Graphene act as if they have no mass and could be potentially 100 times faster than Silicon



(Image: Guanxiong Liu, Alexander Balandin, UC Riverside)

Hardware: Graphene Transistors

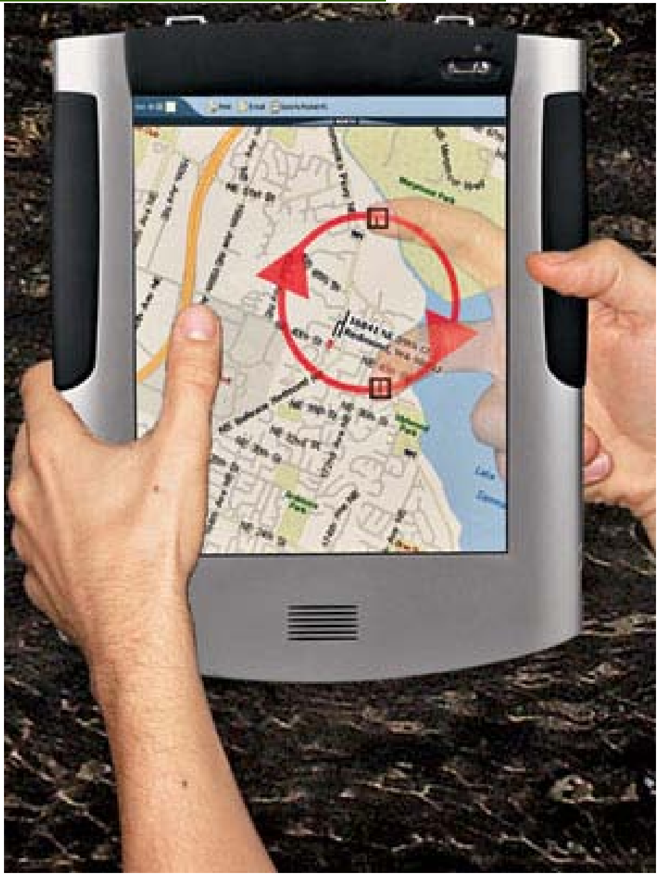
- Potential uses include:
  - Smaller, faster, less power hungry processors
    - Capable of operating in the GHz range
    - One Manufacturer is already looking at a Graphic Processor that can achieve 1 trillion operations per second
  - Faster LCD Screens
    - Higher degree of transparency
    - More rugged than traditional screens
    - Flexible Screens
  - More efficient batteries
    - Very low internal resistance
    - High power carrying capacity

Hardware: Graphene Transistors

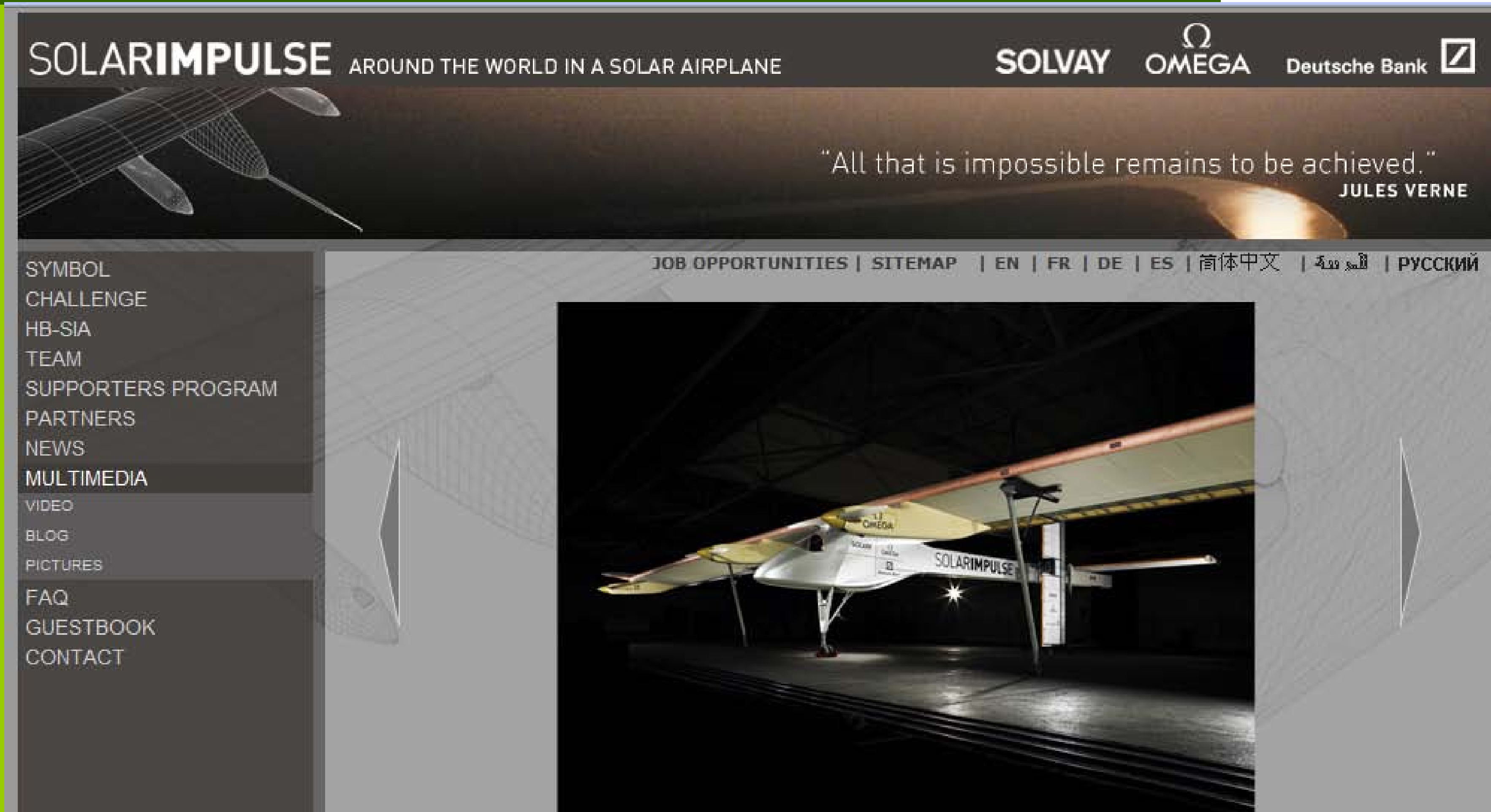
- Potential uses include:
  - Ultra Capacitors
    - Potentially higher power densities than traditional batteries
    - Ideally suited for bursty power demands
      - Regenerative braking
      - Boost applications for short duration loads
      - Energy balancing for power grid to counteract inductive loads
    - Does not wear out like batteries
    - Green Energy power storage
      - Solar and Wind Energy Storage

Applications: Lucid Touch

- Challenge of hand-held devices
  - Too small
  - Fingers cover the area you are trying to touch
  - Difficult to manage for those with large hands
- Microsoft Lucid Touch
  - Uses the back of the device which is typically wasted
  - A large finger can be represented by a small dot
  - Allows for a larger screen



Applications: Solar Powered Flight



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Applications: Solar Powered Flight

- Goals:
  - Fly a manned airplane around the world under solar power
  - Fly a manned non-stop flight around the world under solar power
- Solar Impulse Key Milestones
  - December 3, 2009 Flying Prototype takes off for the first time
    - Low weight: 206 foot wingspan, 3500 lbs
  - July 8, 2010 completed a manned 26 hour flight with solar power only

Applications: Solar Powered Flight

"If Solar Impulse really manages to fly around the world with no fuel, only on solar power, nobody will be able to pretend anymore that it is impossible to do the same for cars, for heating and cooling systems, for computers, so on, and so on."

Bertrand Piccard, President, Solar Impulse, June 26, 2009 at the unveiling of the HB-SIA

Applications: Tesla Motor Company

0-60 mph in 3.7 seconds, 245 miles per charge

Applications: Tesla Motor Company

- Goals:
  - High Performance Roadster with 240 mile range
  - Midsize Sedan by end of 2012
    - Greater Range
    - 45 minute recharge time from standard outlet
    - Price approximately one half of the Roadster
- Current Battery Technology
  - 6,831 Cells
  - 56 kWh

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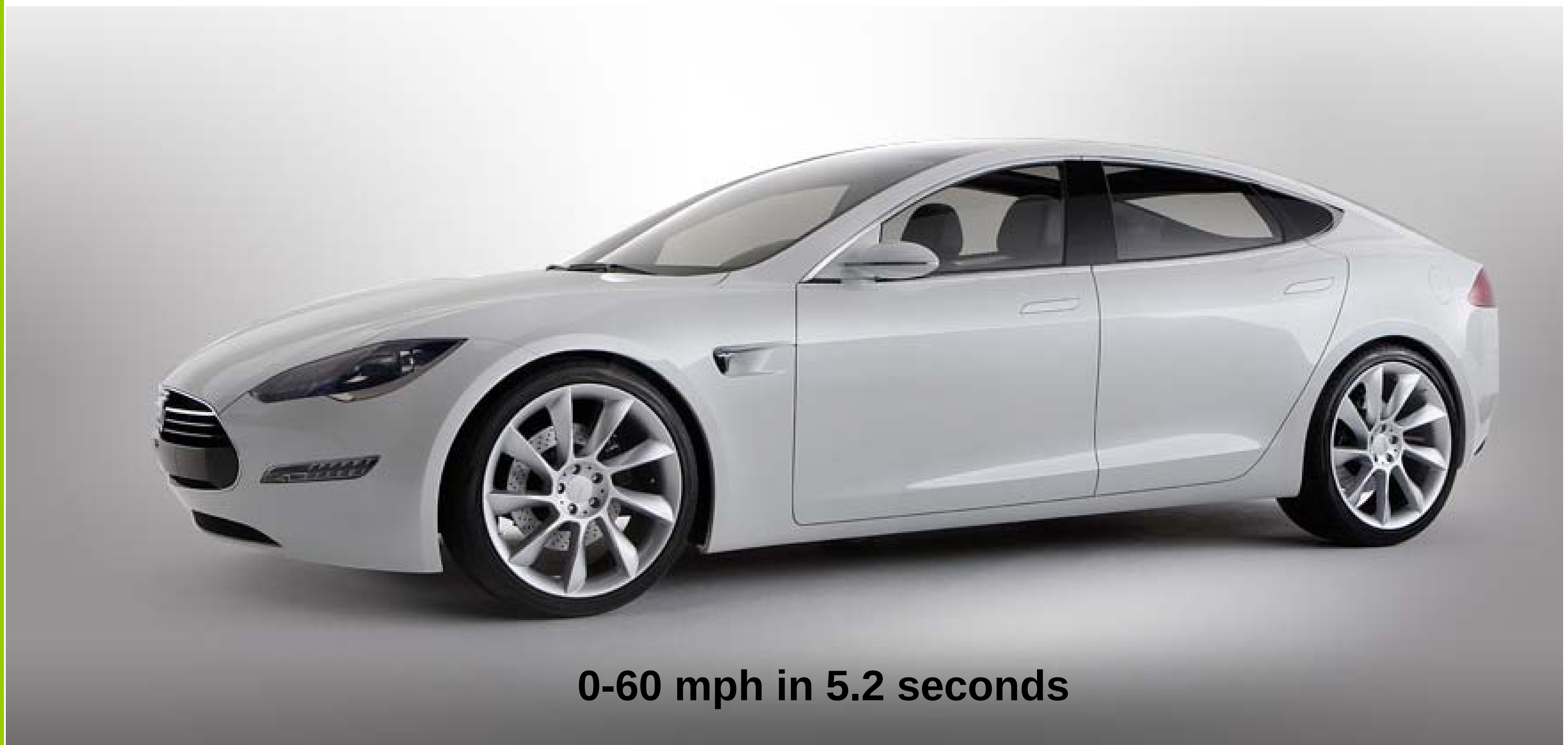
Applications: Tesla Motor Company Model S

300 Mile Range Base Price $49,900 Available 2012



0-60 mph in 5.2 seconds

Applications: Nissan Leaf

100 Mile Range Base Price $33,600 Available Now

0-60 mph in 10.0 seconds

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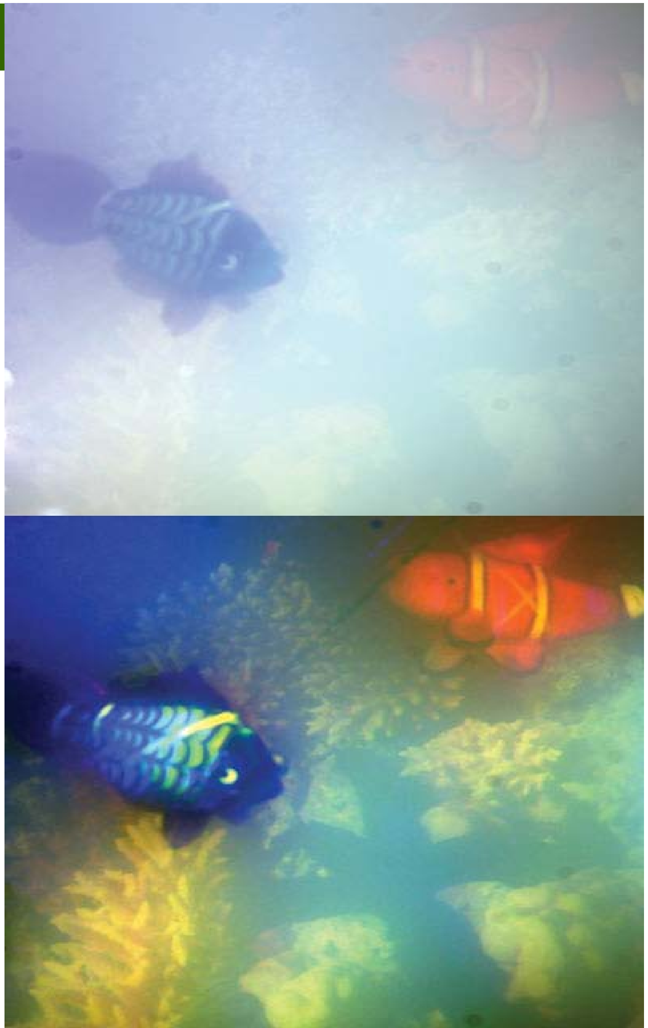
Applications: Computer Vision Systems

- Driving in rain, fog, snow provides unique challenges
  - More light reduces visibility due to back scatter
  - Drivers actually drive faster due to lack of visual references
- Computer Vision Systems
  - Small focused light source that rapidly scans the area
  - Camera captures the results and provides a clear display for the driver



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Applications: Driverless Cars??

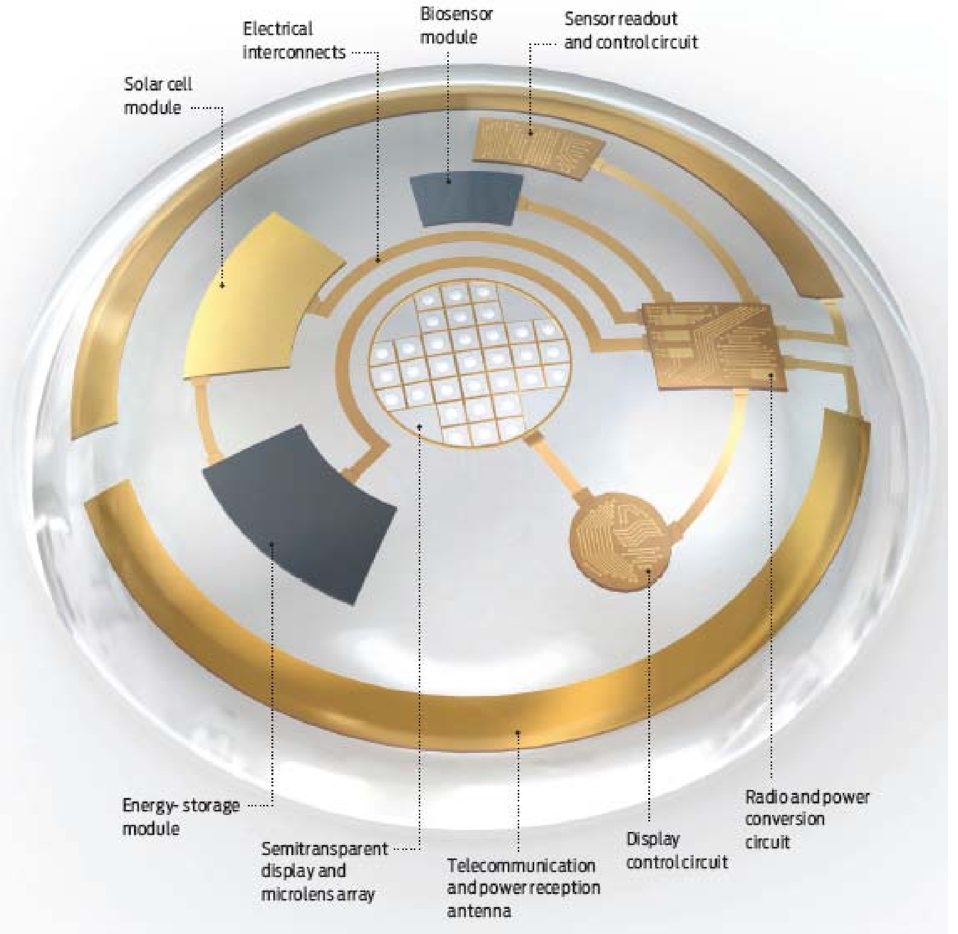
- Why
  - Too easily distracted
  - We are worse drivers than we think
  - Texting
- What is holding us back?
  - Image Processing
  - Human Eye has 125 M Photoreceptors supporting a brain with almost instantaneous processing

http://www.ksl.com/emedia/slc/220/22044/2204461.jpg

Photo: Eugenio Culurciello/e-Lab

Applications: Contact Lense

- Contact Lenses with imprinted circuits (Babak A. Parviz, University of Washington, Seattle)
  - Biomedical sensing
  - Vision enhancement
  - Speech to text for hearing impaired
  - Heads-up-Display
  - Video Projection



How We Interact

- The digital evolution has rewired the brains of its users

  "I don't read books," he said. "I go to Google, and I can absorb relevant information quickly." O'Shea explained that he can use Google (GOOG) Book Search to grab the information he needs. "But sitting down and going through a book from cover to cover doesn't make sense," he said. "It's not a good use of my time, as I can get all the information I need faster through the Web. You need to know how to do it—to be a skilled hunter.“ Joe O'Shea, 22-year-old student body president at Florida State University, "How Digital Technology Has Changed the Brain" (Part 2 of 8 by Don Tapscott, BusinessWeek.com, 11/3/08)

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How We Interact

- The digital evolution has rewired the brains of its users
  - Tend to process visual information faster
  - Have a greater ability to scan large amounts of information for the portions they need
  - They are faster at switching tasks
  - They are better at tuning out outside disturbers

Thank you

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