Flexible Electronics

Opportunity and Issue

Industrial Technology & SRB Meeting

Taipei, Taiwan

August 14-18, 2006

Jack Chang

City University of Hong Kong

Flexible Electronics

Outline

- Introduction
- Motivation
- Focused Areas
  - Display
  - Photovoltaic
  - Memory
- Manufacturing Technology
- Conclusion

Flexible Electronics Introduction

- Worldwide Chip Sales will be 250B at YE 2006
- Moore’s prediction continue to be held reasonably true
- Electronics becoming, if not already ubiquitous

Flexible Electronics Motivations

- Cost/light weight/Large area Applications
- Flexibility for New Applications

- Easier Integration of electronics with integrated optics
- Smaller Dimension Requirement

Flexible Electronics

Success will depend on

- System approach
- Team of people with different skills
- “Stay in” power
- Tackle highest hurdle first
- Manufacturing technology

Flexible Electronics

Potential Applications

- Display
- Smart ID Cards
- Photovoltaic Devices
- Memory Devices
- Transducers
- Etc.

Flexible Electronics

Display

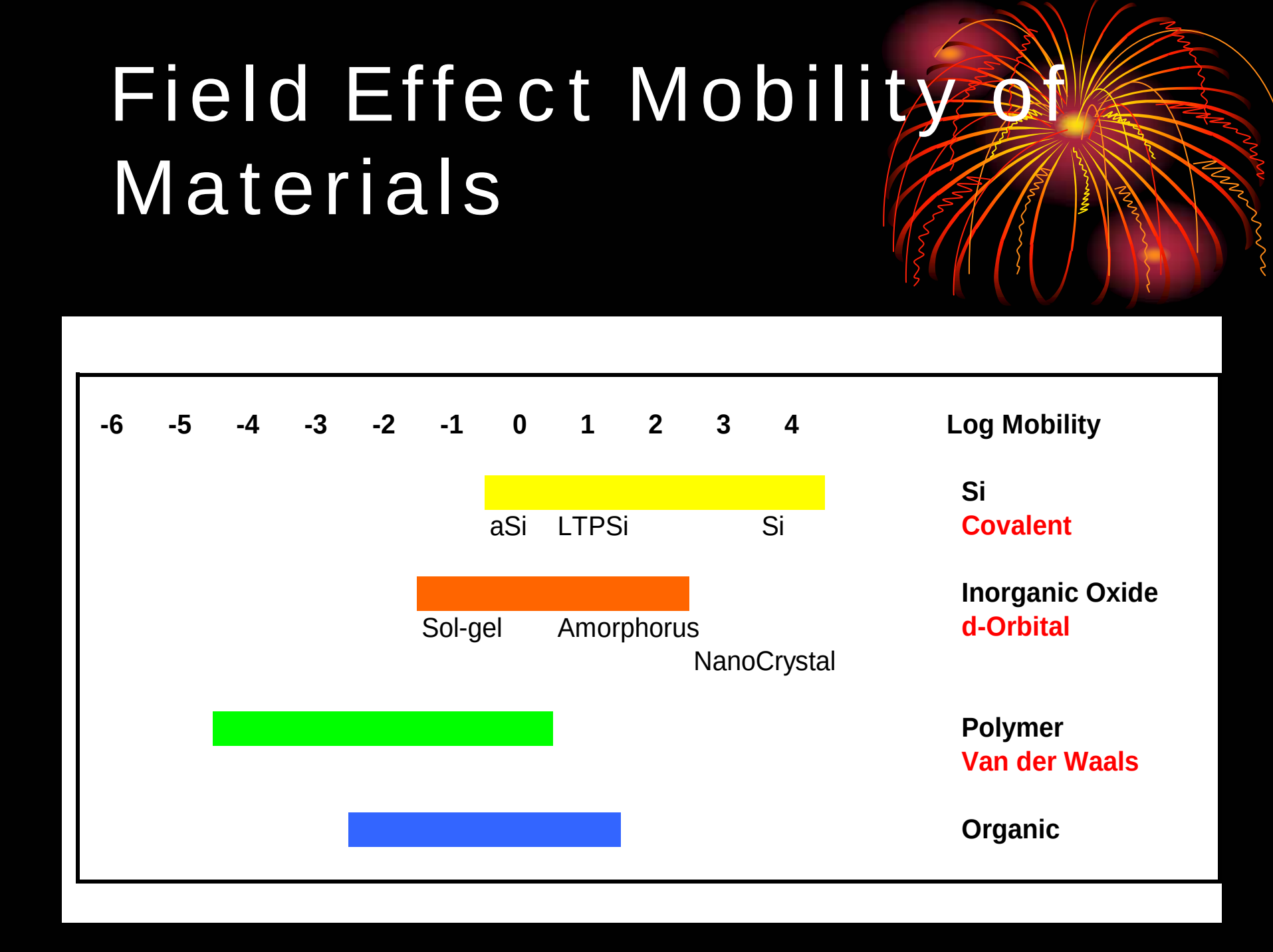
Opportunities in Flexible Display

- Display for signage
  - Dynamic
  - Variable Information
- Smart ID card
  - Article of Commerce
  - Personal ID
- Price label
  - Accurate Pricing
  - Dynamic Pricing
- Wearable display
  - Fashion
  - Military

Flexible Electronic Components

- Materials
  - Semiconducting Materials
    - Electrode Materials
    - Dielectric Materials
    - Encapsulating materials
  - Flexible Support

Field Effect Mobility of Materials

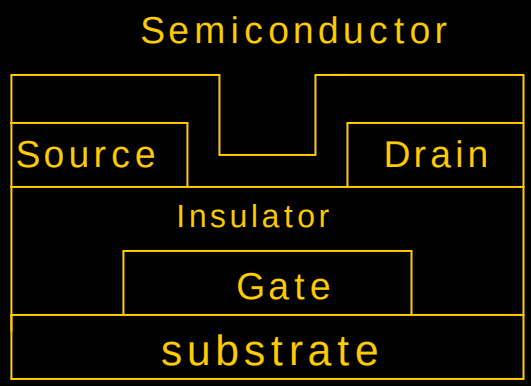


Flexible Electronics

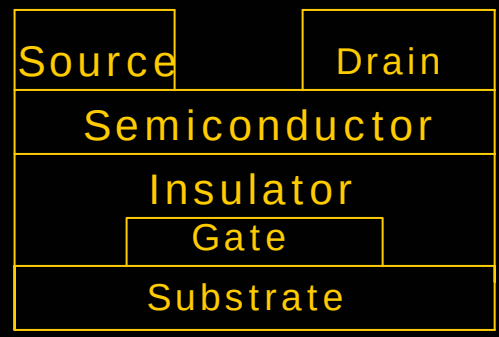
Design of Organic Semiconductor

- Reduce reorganization energy between states
  - Rigid Molecules
- Enhance intermolecular electronic coupling
  - Pi interaction
  - Molecular Alignment
- Polymorphic
  - Crystal packing is important for mobility

TFT Device Configurations



Bottom Contact Device



Top Contact Device

Flexible Electronics

Support Issues

- Tg
- Cost
- Surface Smoothness
- Conveyance
- Transparency
- Conductive Coating
- Barrier Layers

Flexible Electronics

Memory Device

Flexible Electronics

Memory Device Structure

MIM Structure of Memory Device

Flexible Electronics

Memory Device

- Mostly in MIM Structure
- Two Major Approaches
  - Donor-Acceptor Polymer (DRAM and WORM)
  - Nanometal cluster /organic composite (WORM)
- Solution Processible
- High On/Off Ratio, Low Voltage Operation

Flexible Electronics

Memory Device

- Low Power
- High Density
- Long Endurance
- Response Time

Flexible Electronics

Photovoltaic Device

Flexible Electronics

Photovoltaic Device

- All energy consumed on earth in one year equals to sunlight striking earth in one hour ($4.3 * 10^{20}$ J)
- Solar cell industry is expected to be about 10 B$/year business
- Growth Rate is 35-40%
- Solar cell only account for one millionth of total energy consumed
- Must dramatically reduce cost by a factor 50 to compete with fossil energy

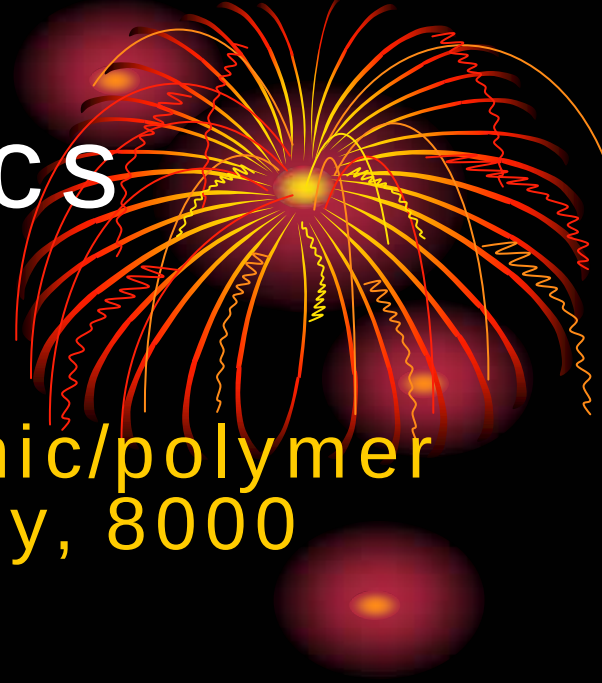
Flexible Electronics

Photovoltaic Device

- Inorganic
  - Si, CdTe
- Organic/Polymer
  - CuPc/C60 P3HT/PCBM
- Hybrid
  - SiNW/Oragnic

Flexible Electronics

Photovoltaic Devices



- Solution Processible organic/polymer HJ device. >5.5% efficiency, 8000 hrs

- Optimize absorption of solar spectrum
- Optimize exciton diffusion length
- Molecular alignment
- Overall optics of the PV
- // and -- cells

Flexible Electronics

Energy Savings

- WOLED may offer considerable energy saving in lighting
- R2R manufacturing is necessary to meet the cost objectives
- This is a challenge!!

Flexible Electronics

Manufacturing Technology

Manufacturing Process
(Current Process)

- Cleaning
- Film Deposition (sputtering, spin coating)
- Impurity Doping (Ion Implantation, annealing, diffusion)
- Lithographic Patterning
- Etching

Manufacturing Technology

Issues

- Large numbers approaches have been explored by academics
- No one technology today can meet the resolution, tolerance and productivity simultaneously
- There is a real urgent need.
- Taiwan is in a good position to take the lead due to its expertise in precision and large scale manufacturing.

Flexible Electronics

Conclusion

- Not in displacement of existing applications currently filled by conventional semiconductor

but

- Expand into the low cost/light weight/large area/flexible applications
- Material/Device design/Manufacturing Processes will have to be co-developed

Flexible Electronics

Key Messages

- Large market demand for flexible electronics does exist
- Materials are essential, but not sufficient
- Holistic approach is important
- Cost is a key driver
- IP management will be an issue

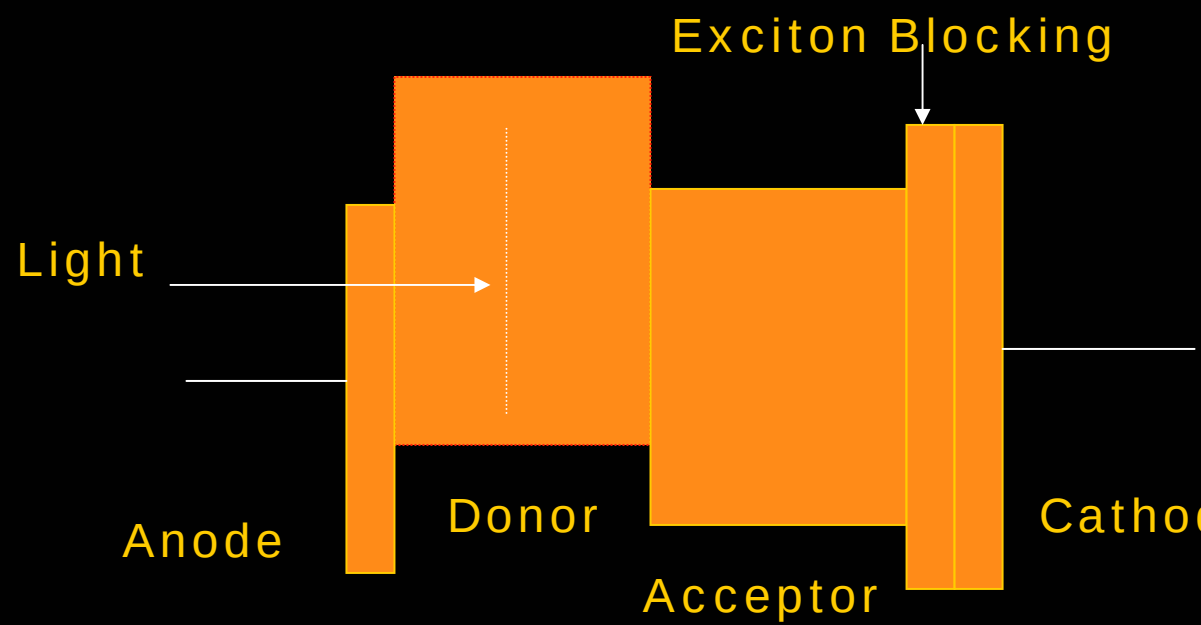
Flexible Electronics

Thank You For Your Attention

Flexible Electronics

Photovoltaic Cell

PV Cell



Flexible Electronics

Energy Savings

- Cumulative electricity savings from 2005-2025 in US along would be US$ 125B
- It will defer 40 (1000MW) power generator
- The revenue in 2025 for USA is projected to be US$ 10B/year