



inEMI

International Electronics Manufacturing Initiative

Materials for Printed Electronics

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Motorola*

Advancing manufacturing technology

Printed & Organic Electronics Roadmap

Goal: Develop industry-wide Printed & Organic roadmap to establish supply chain

Strategy:

- Publish internationally accepted printed and organic electronic roadmap.
- Project Lead: Motorola



Tactics

- Phase 1: Agree to partner with Organic Electronics Association to deliver a combined iNEMI and OEA Roadmap
- Phase 2: Initiate roadmap drafting effort and agree to outline for combined document

Milestones & Issues

- Phase 1.....Q407
- Phase 2Q108
- P&O Roadmap issuedQ109
- ISSUES:

Printed & Organic Electronics Roadmap

Team Members



Cornell University



State University of New York



iNEMI P&O Electronics Roadmap

ORGANIC & PRINTED ELECTRONICS

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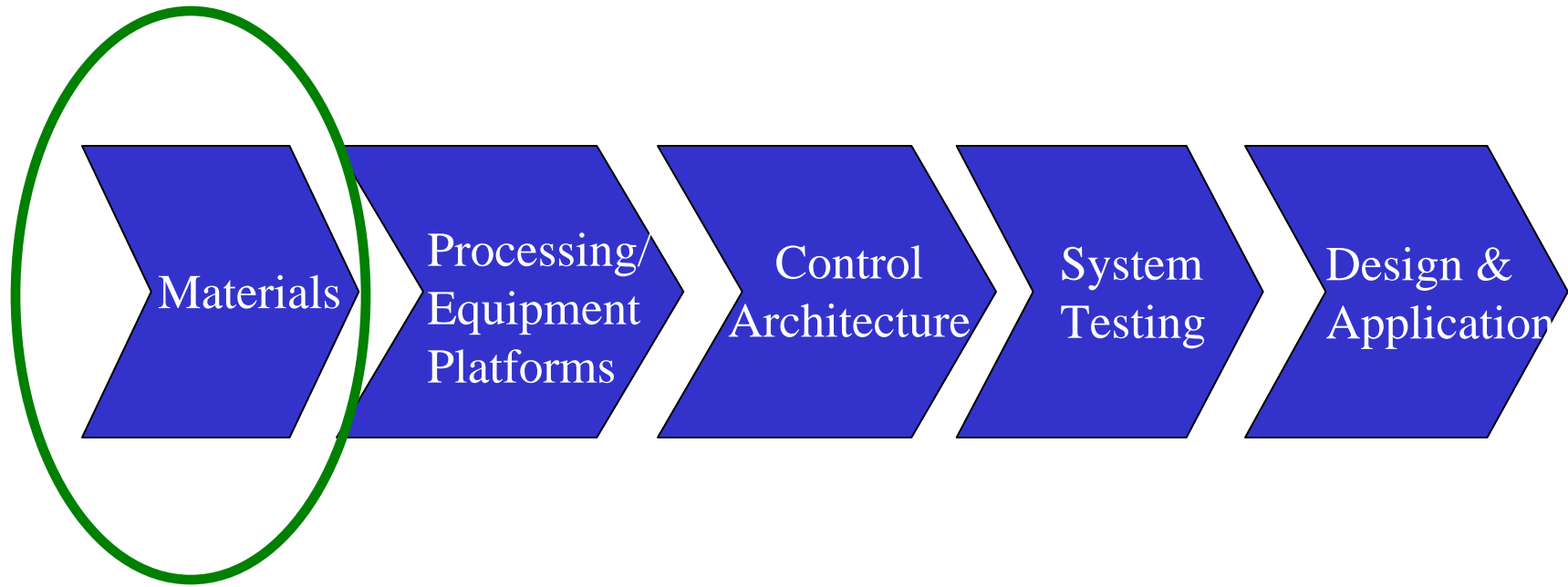
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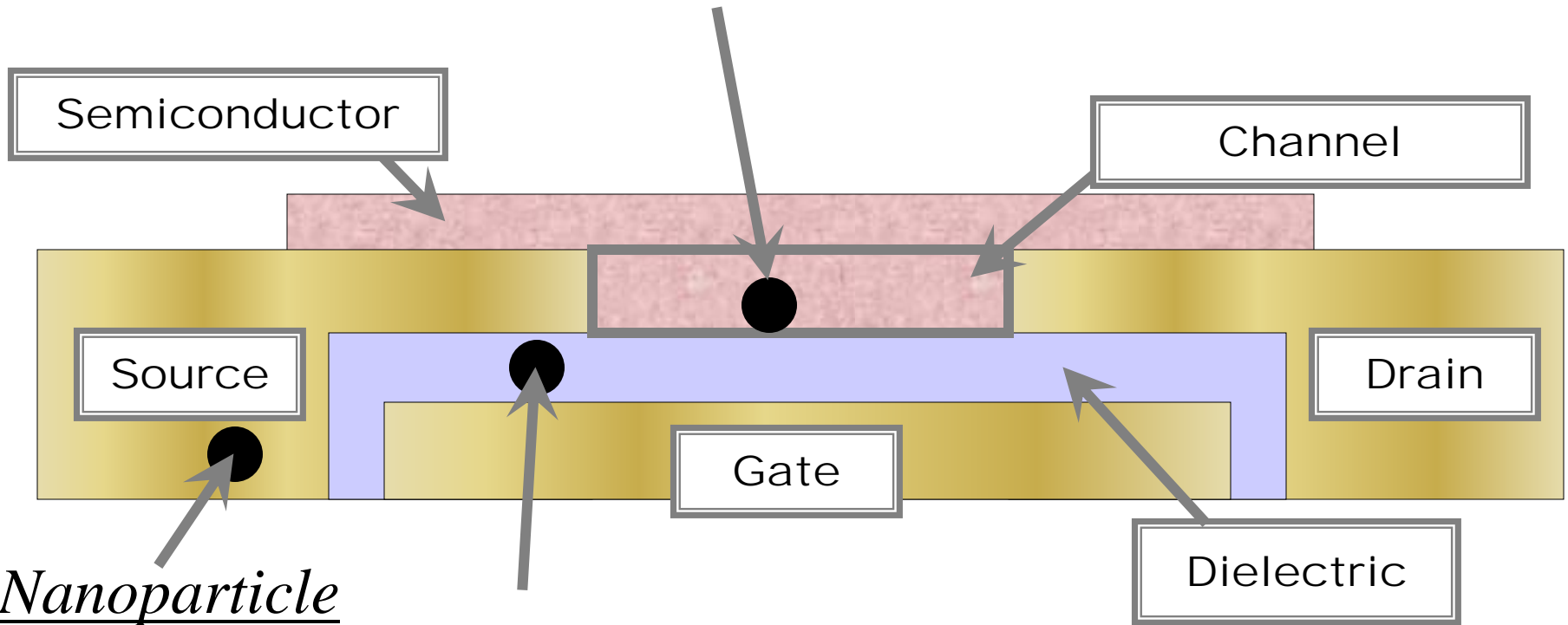
Printed Electronics Supply Chain



Functional ink suppliers are offering a variety of organic polymer, small molecule, and inorganic nanoscale particle suspensions.

Elements of a Printed Transistor

Ordering in semiconductor material
at charge injection interface



Nanoparticle
suspensions

Polymers and nanocomposite
dielectric materials

Ink Properties Determine Printing Process

Materials/Inks	Electrical Properties	Printing Technologies
PTF Conductors Conductive Polymers Nanoparticle Conductors	High Conductivity (Sheet resistance ~ mohm/sq)	Flexography Lithography Screen Printing Micro-dispensing Jetting Spin-coating
PTF Dielectrics Dielectric Polymers	High/Low Dielectric Const.	
Semiconductor Inks Organic Inorganic	High Mobility	

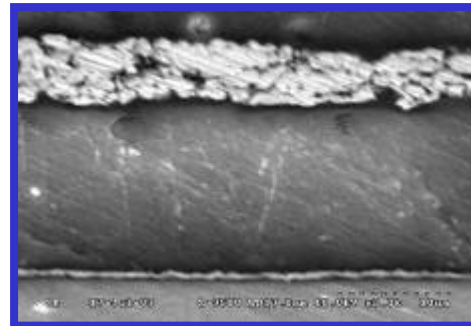
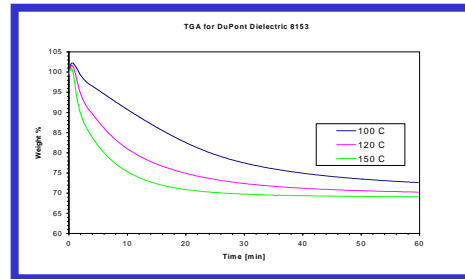
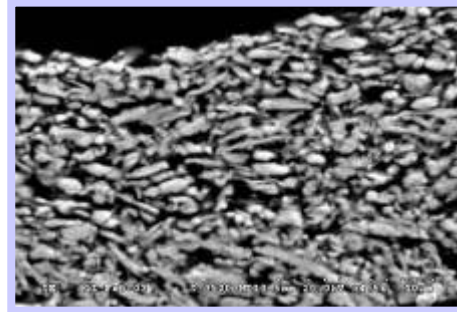
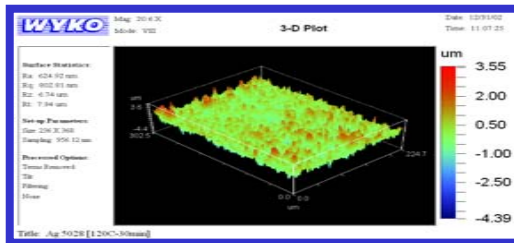
Flexible Substrates Combined with Functional Inks Enables Printed Electronics Products

- ✓ **Low-cost**
- ✓ **Flexible/Spoolable**
- ✓ **Thermally, mechanically, and chemically stable**
- ✓ **Porous free surface**
- ✓ **Low surface roughness**
- ✓ **Adequate surface energy**
- ✓ **Good adhesion and cohesion**

Functional Ink Attributes

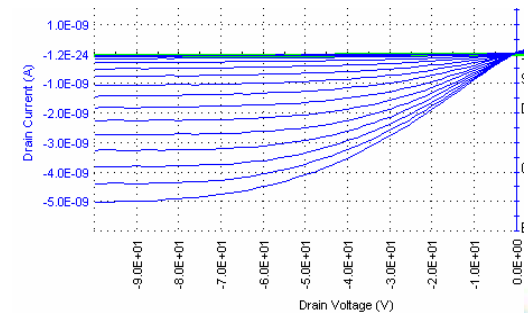
Property and Process Characterization

- Viscosity
- Thermal Gravimetric Analysis
- Transferability
- Solvent resistance
- Deposition thickness
- Surface topography



Electrical Performance

- Conductivity
- Resistivity
- Capacitance
- Mobility
- On/Off ratio
- IV characteristics



INEMI

Ink Characterization

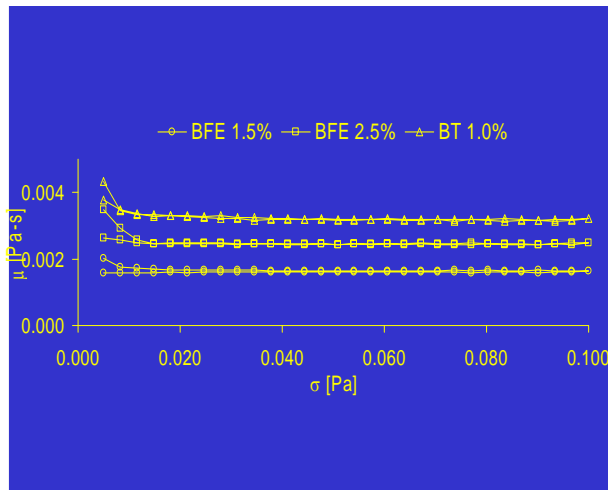
- Characterize rheological properties of the electronic materials

Surface tension
Density

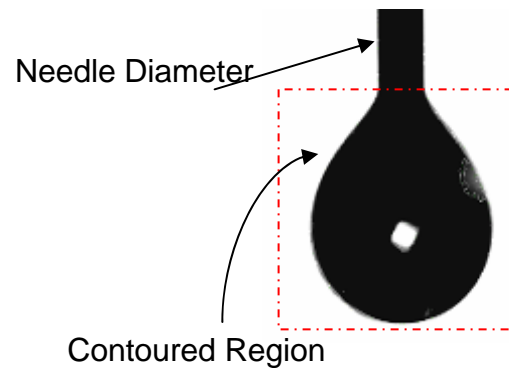
Viscosity
Cure schedule

- Identify materials that have compatible properties for use with the ink jet systems

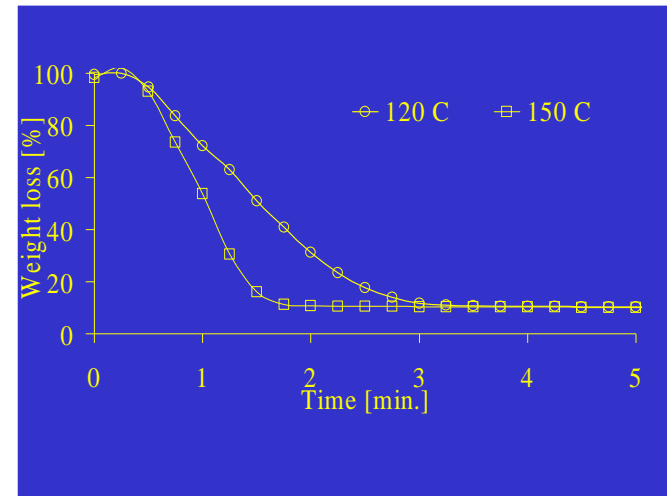
Viscosity



Surface Tension



Cure Schedule



Additional Processing Parameters

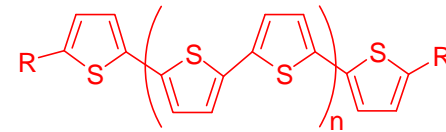
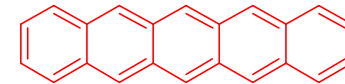
- Shelf life
- On-press life
- Storage condition
- Thermal vs. UV curing
- Other curing techniques (e-beam, chemical, laser, microwave, etc.)
- Curing conditions compatible with fabrication process
- Solvent reclamation

Functional Electronic Inks - Conductive, Semiconductive, and Dielectric Inks

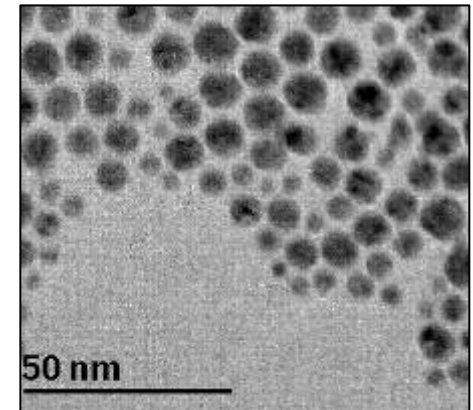
Attributes

- Characteristics similar to traditional electronic materials
- Solution processable for low cost manufacturing
- Robust synthesis/formulating routes
- Materials and device stability in-air
- Large area processing routes demonstrated
- Devices fabricated on graphic arts manufacturing printing platforms

Semiconductor Inks



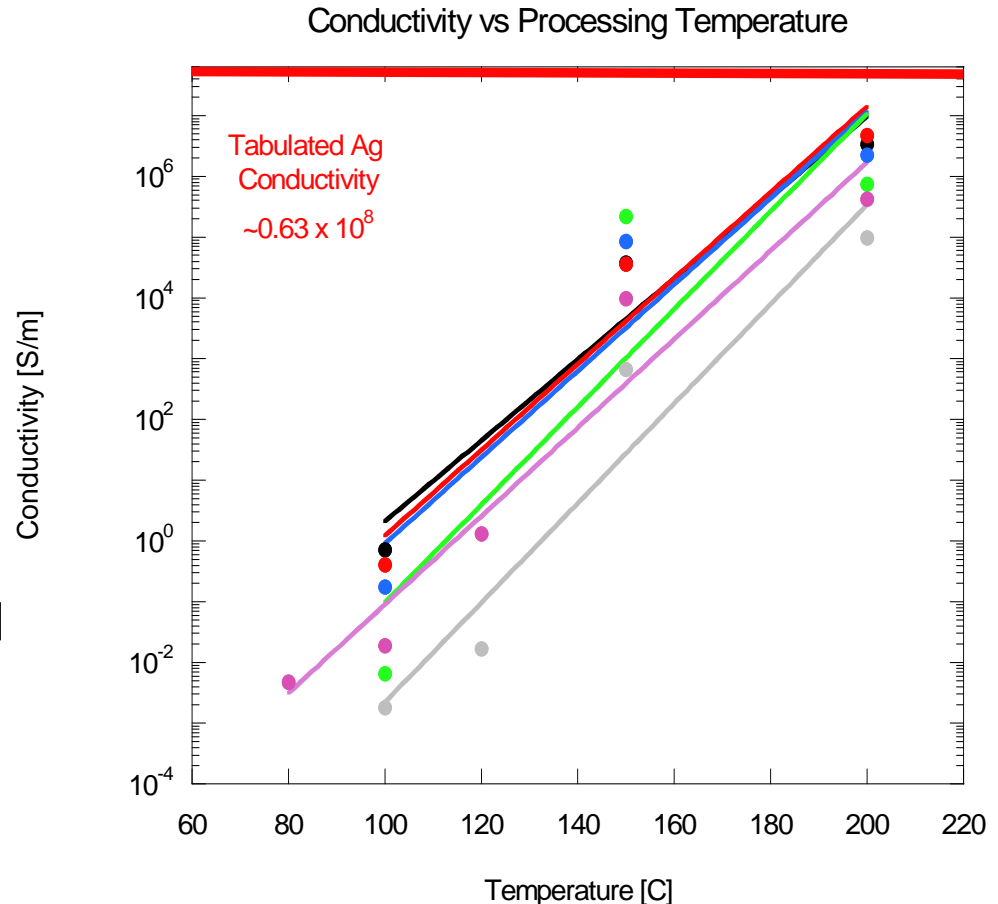
Silver Nanoparticle Conductive Inks



Electronic Functional Inks

Conductive Ink Attributes

- High conductivity
- Solution processable
- Fine particle sizes
- Broad processing window
- Low cost
- Large area printing process
- Compatible with substrate and other FET inks

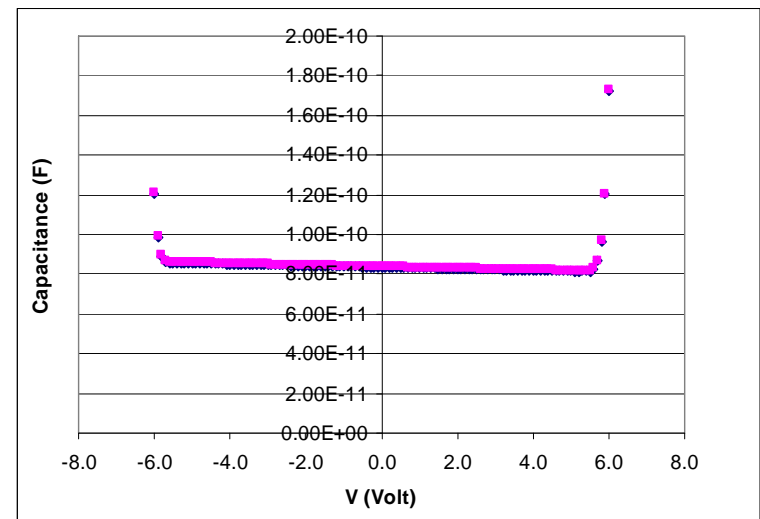
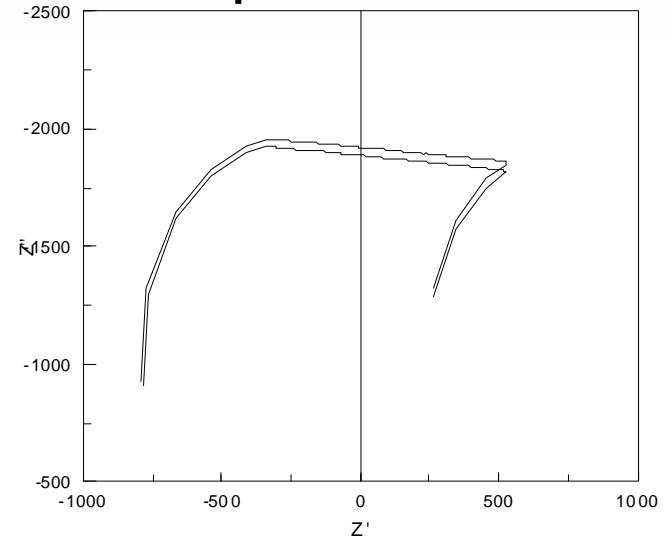


Electronic Functional Inks

Dielectric Ink Attributes

- Dielectric constant (ϵ)
- Solution processable
- Thin, uniform films
- Compatible with other FET inks
- Pinhole free
- Low surface roughness

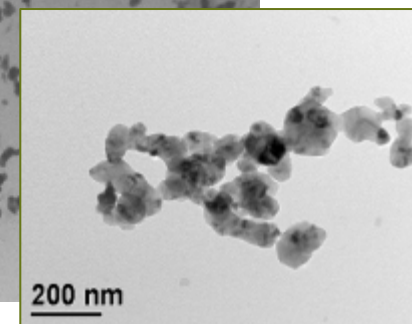
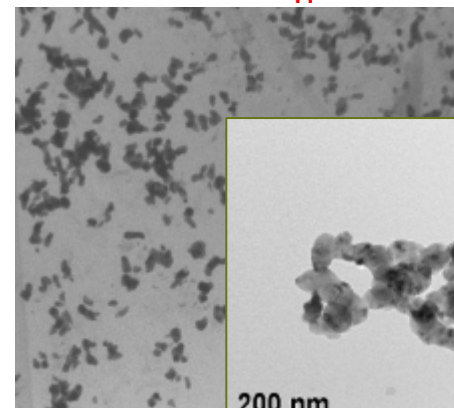
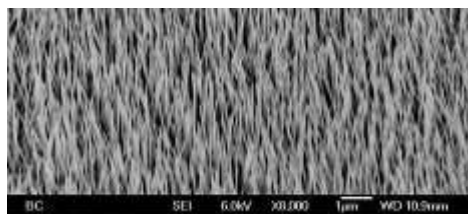
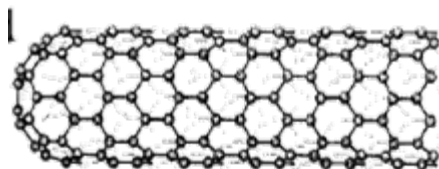
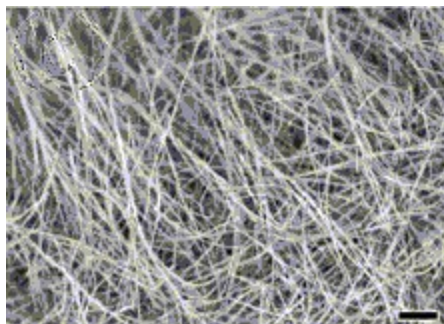
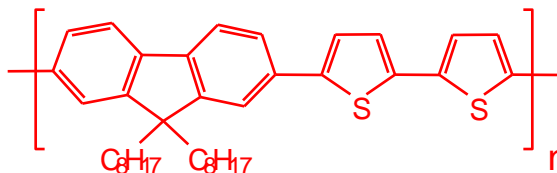
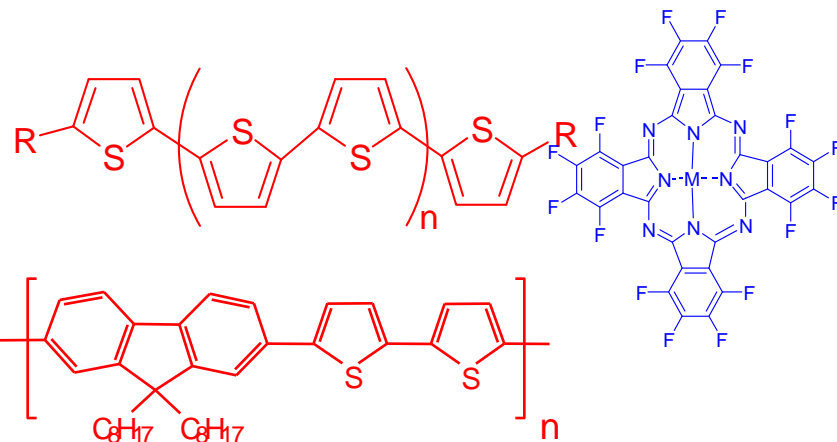
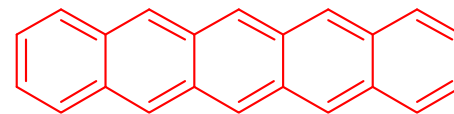
Printed Capacitor C-V Characteristics



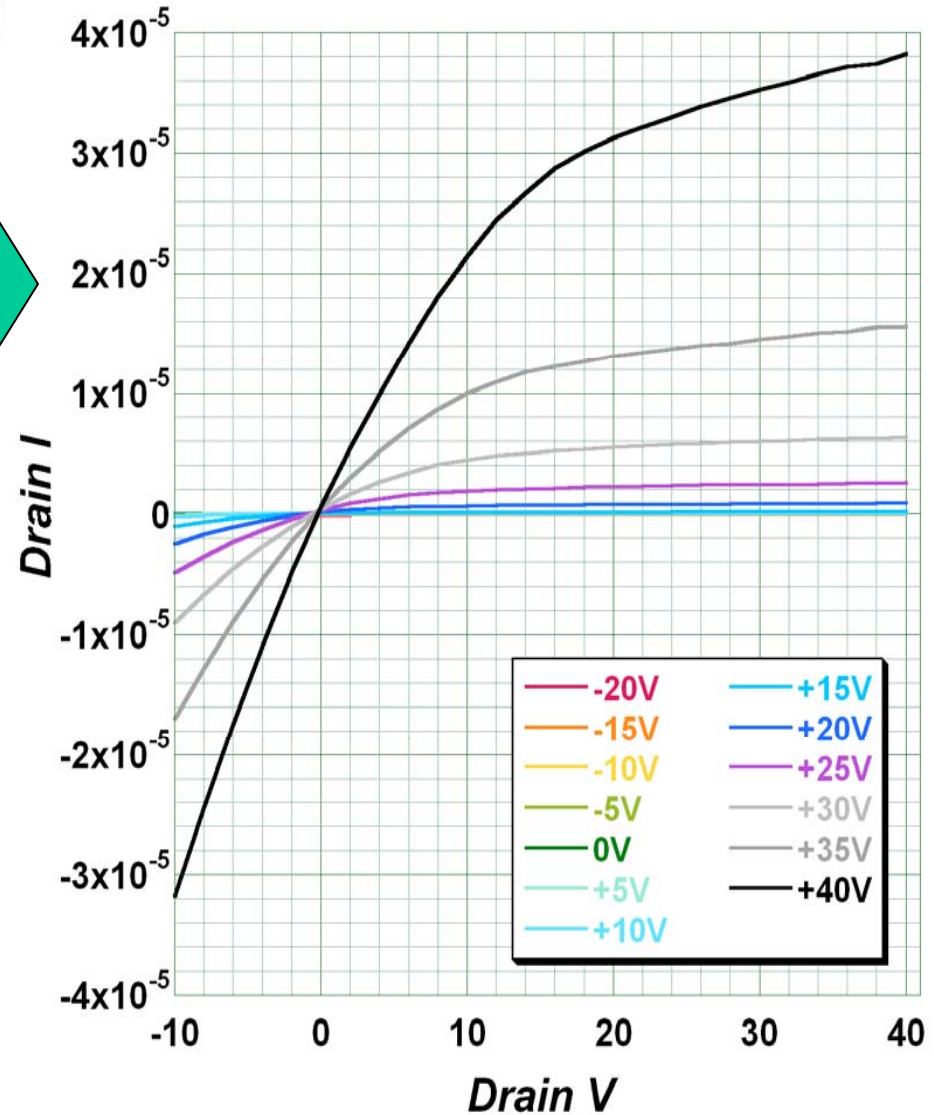
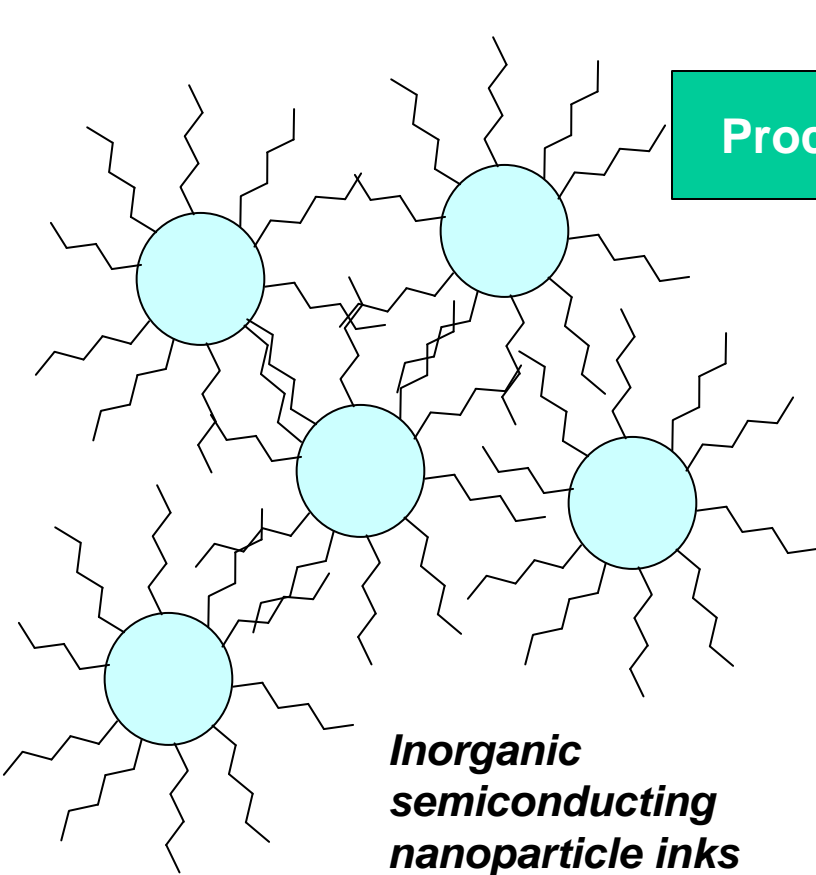
Electronic Functional Inks

Semiconductive Ink Attributes

- High mobility
- Solution processable
- Compatible with printing platforms and other inks
- Matching work function
- In-air stability
- Environmental friendly



Inorganic Ink Device Performance



Printed & Organic Electronics Roadmap – Next Steps

- **Call for volunteers – Q4 2007**
- **Roadmap Kickoff Meeting – February 20, 2008**
 - Review 2007 Roadmap
 - Highlight new topics for inclusion
 - Revise/Update sections
- **Bi-weekly conference calls - TBD**
- **Updated draft due – August 6, 2008**
- **Final version due – September 22, 2008**
- **2009 Roadmap released to Public – Q1 2009**

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