Sensor Technologies on Flexible Substrates: In-Space Manufacturing

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In-Space Manufacturing

• No need to wait for resupply
• Fabrication on-demand
• Printers and Functional Inks
• Compliant or woven substrates allow easy integration into flexible or compliant surfaces

• Technologies include:
  – Energy generation & storage
  – Communication
  – Integrated circuits
  – Sensors
Printing Materials and Methods

**Manufacturing**
- Roll-to-Roll
- Screen Printing
- Gravure
- Transfer
  - **INK JET**
  - **PLASMA JET**

**Substrates**
- Silicon
- Kapton
- Metal
- Glass
- Ceramic
- **PAPER**
- **POLYMER**

**Inks**
- Conductor
- Semiconductor
- Insulator
- Passivation
- Catalyst
- Biological agent

Carbon Nanotube Based eInk and Printing
Advantages of Paper

• Sensors fabricated on paper
  • Gas sensor, chemical sensor, bio sensor, and strain gauge
  • Detection of structural defects and cracks, structural health monitoring
  • Commercial: Intelligent packaging, advertising banner, newspaper

• Features
  • Flexible, bendable, foldable
  • Bio-degradable: green technology
  • Robust at cryogenic temperatures
  • Role-to-role printing or ink-jet printing process
  • Cheaper than solid-state sensors
  • Biomedical: Single-time use, disposable
Printing Approaches

Fountain Pen:

Inkjet:

Atmospheric Pressure Plasma Jet:
Atmospheric Pressure Plasma Jet

- Glass tube or nozzle; two copper band electrodes (20 mm apart)
- Helium atmospheric plasma
  - can introduce different gases for chemistry control (e.g. hydrogen for reduction)
- Nanocolloids, organic materials etc. transported as aerosol by carrier gas
- Spot size can be altered by changing print head nozzle diameter
- Multiple jets for different coatings
Technology Demo: Chemical Sensing

- Humidity and NH$_3$ Sensor on Paper

- NH$_3$ Sensor on Textiles
Technology Demo: Biological Sensing

- Sensors on Paper
- Sensor on Polyimide
Sensors on Flexible Substrates for Next Generation EVA Suit

- Human health monitoring
  - Skin Wearable Sensors
    - Sweat, saliva, urine, blood
    - Health & human performance
    - pH, proteins, ions, etc.
  - In Suit Sensors
    - Breath
    - Health & human performance
    - O₂, CO₂, acetone, NO₂
- Environmental monitoring
  - Gas or vapor
    - CO, NH₃, hydrazine
- Structural Health Monitoring
  - Strain
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