Printed Wearables

Electronic Inks for the Wearable World
Outline

1. DuPont Enables Printed Wearables
2. Directions in Wearable Tech
3. Smart Clothing
   - Printed Wearable Possibilities
   - New Product Introduction
   - Construction Examples
   - Performance Testing
4. Summary
The DuPont Legacy in Clothing Innovation Continues

• From the brand that introduced Nylon®, Lycra®, and Kevlar® to the textile industry

• Answering the question: “Can we **print a circuit** into a shirt, **connecting sensors** to a central device?”

• Microcircuit Materials (MCM) is a leading innovator and high-volume supplier of electronic inks and pastes
# Directions in Wearables

<table>
<thead>
<tr>
<th>Feature</th>
<th>Smart Clothing</th>
<th>Wearable Tech</th>
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</thead>
<tbody>
<tr>
<td>Look</td>
<td>• Digital Enhancements</td>
<td>• Compliments Smartphone</td>
</tr>
<tr>
<td>Feel</td>
<td>• Fabric</td>
<td>• Fun and Simple</td>
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<tr>
<td>Function</td>
<td>• Health and Environment Monitoring • Performance Enhancement</td>
<td>• Advanced Plastic or Metal</td>
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<tr>
<td></td>
<td></td>
<td>• Device interface</td>
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<tr>
<td></td>
<td></td>
<td>• Health and Environment Monitoring</td>
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<tr>
<td></td>
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<td>• Information and Communication</td>
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</tbody>
</table>

## Conceptual Examples

- **Ralph Lauren**
- **Nike iWatch Concepts**
Printed Wearable Possibilities

Prototype Biometric Fitness Shirt

• A manufacturing-ready solution for smart clothing enabled by DuPont electronic inks
• Thin and comfortable
• Washable up to 100 cycles
• Stable through repeated elongation
• DuPont is developing complete material suite: conductors, encapsulants, and sensors

Shirt developed in cooperation with Maxim Integrated
Shirt on display at Demonstration Alley and DuPont Booth E16
## New Products

<table>
<thead>
<tr>
<th>Material</th>
<th>Product ID</th>
<th>Description</th>
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<tbody>
<tr>
<td>Silver Conductor</td>
<td>PE872</td>
<td>Conductor for signal transfer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Stretchable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Washable</td>
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<tr>
<td>Encapsulant</td>
<td>PE772</td>
<td>Wearable Applications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Stretchable</td>
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<tr>
<td></td>
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<td>• Washable</td>
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</table>
Lamination Construction Examples
Printed Sensors

- Fabric or Film
- Thermoplastic Polyurethane
- Stretchable Conductor
- Stretchable Sensor
- Encapsulant Overprint
Lamination Construction Examples

Printed Conductor Traces

- Fabric or Film
- Thermoplastic Polyurethane
- Encapsulant Overprint
- Stretchable Conductor
Conductivity Measurements

- 20 cm trace, 0.5 cm wide → 0.7 Ω
- Conductors work well on TPU films and synthetic fabrics
- Encapsulant overprint defines connection pads and sensor areas
- Stretchable sensor materials available for testing

The above data is based on internal, controlled experiments and evaluations within particular test designs and parameters and should not be interpreted as establishing specifications or performance expectations in any particular environment or application or as establishing any warranty or guarantee.
Stretchability and the Effects of Strain

- Conductor printed on TPU film, 10cm trace length
- **Trace width & strain relief design** can enable **>15% strain and 4% oscillating strain** with minimal change in resistance
- Data generated in collaboration with NCSU and ASSIST (Booth T30)
Washability – Various Solutions Available

- Ink system is PE872 conductor and PE772 encapsulant
- Stable performance demonstrated with overprint approach
- Testing done by CLOTHING+, who integrate flexible circuits into textile structures.

The above data is based on certain controlled experiments and evaluations within particular test designs and parameters and should not be interpreted as establishing specifications or performance expectations in any particular environment or application or as establishing any warranty or guarantee.
Direct Print on Fabric

- Customers may choose direct print on fabric
- Best performance to date with high density synthetic fabrics
- Overprint with encapsulant recommended
- Washing remains a challenge for direct print approach
Electronic Inks for the Wearable World

• DuPont is introducing a stretchable ink suite for the wearables market
• Manufacturing-ready solution for smart clothing enabled by electronic inks
  – Thin and comfortable
  – Washable up to 100 cycles
  – Stable through repeated elongation
• Screen print formulations as needed for high volume and low cost
• Material selection guidance and post-sales support available
• Currently engaging commercial partners to expand wearable market development
Together we can accomplish what no one can do alone.