



## Printed Wearables

Electronic Inks for the Wearable World

*Welcome to*  
**The Global Collaboratory™**



Printed  
Electronics  
**USA2014**

# 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<sup>®</sup>, Lycra<sup>®</sup>, and Kevlar<sup>®</sup> 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

Feature	Smart Clothing	Wearable Tech
<b>Look</b>	<ul style="list-style-type: none"> <li>• Digital Enhancements</li> </ul>	<ul style="list-style-type: none"> <li>• Compliments Smartphone</li> </ul>
<b>Feel</b>	<ul style="list-style-type: none"> <li>• Fabric</li> </ul>	<ul style="list-style-type: none"> <li>• Fun and Simple</li> <li>• Advanced Plastic or Metal</li> </ul>
<b>Function</b>	<ul style="list-style-type: none"> <li>• Health and Environment Monitoring</li> <li>• Performance Enhancement</li> </ul>	<ul style="list-style-type: none"> <li>• Device interface</li> <li>• Health and Environment Monitoring</li> <li>• Information and Communication</li> </ul>

## 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

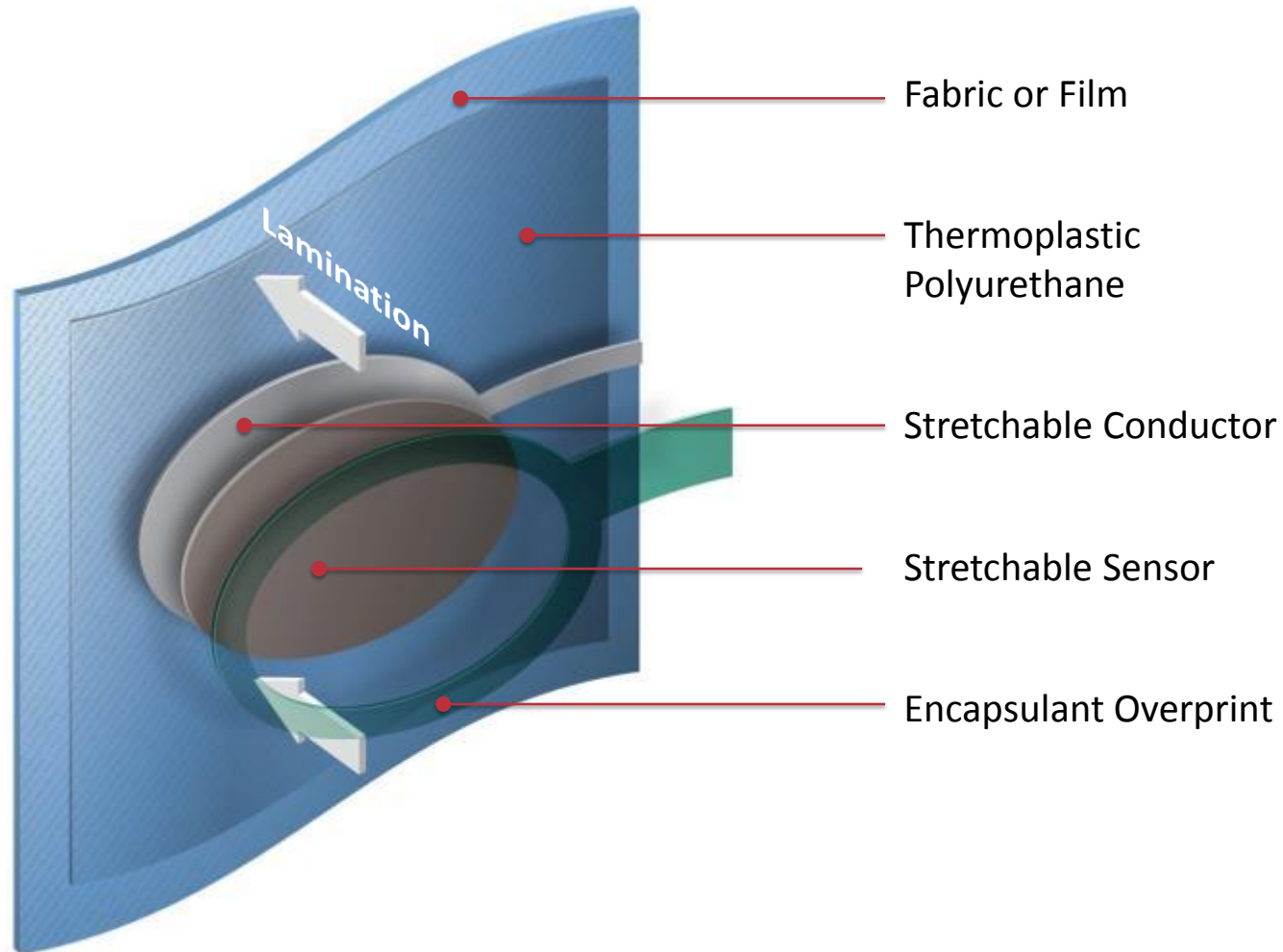
# New Products

Material	Product ID	Description
Silver Conductor	PE872	Conductor for signal transfer <ul style="list-style-type: none"> <li>• Stretchable</li> <li>• Washable</li> </ul>
Encapsulant	PE772	Wearable Applications <ul style="list-style-type: none"> <li>• Stretchable</li> <li>• Washable</li> </ul>



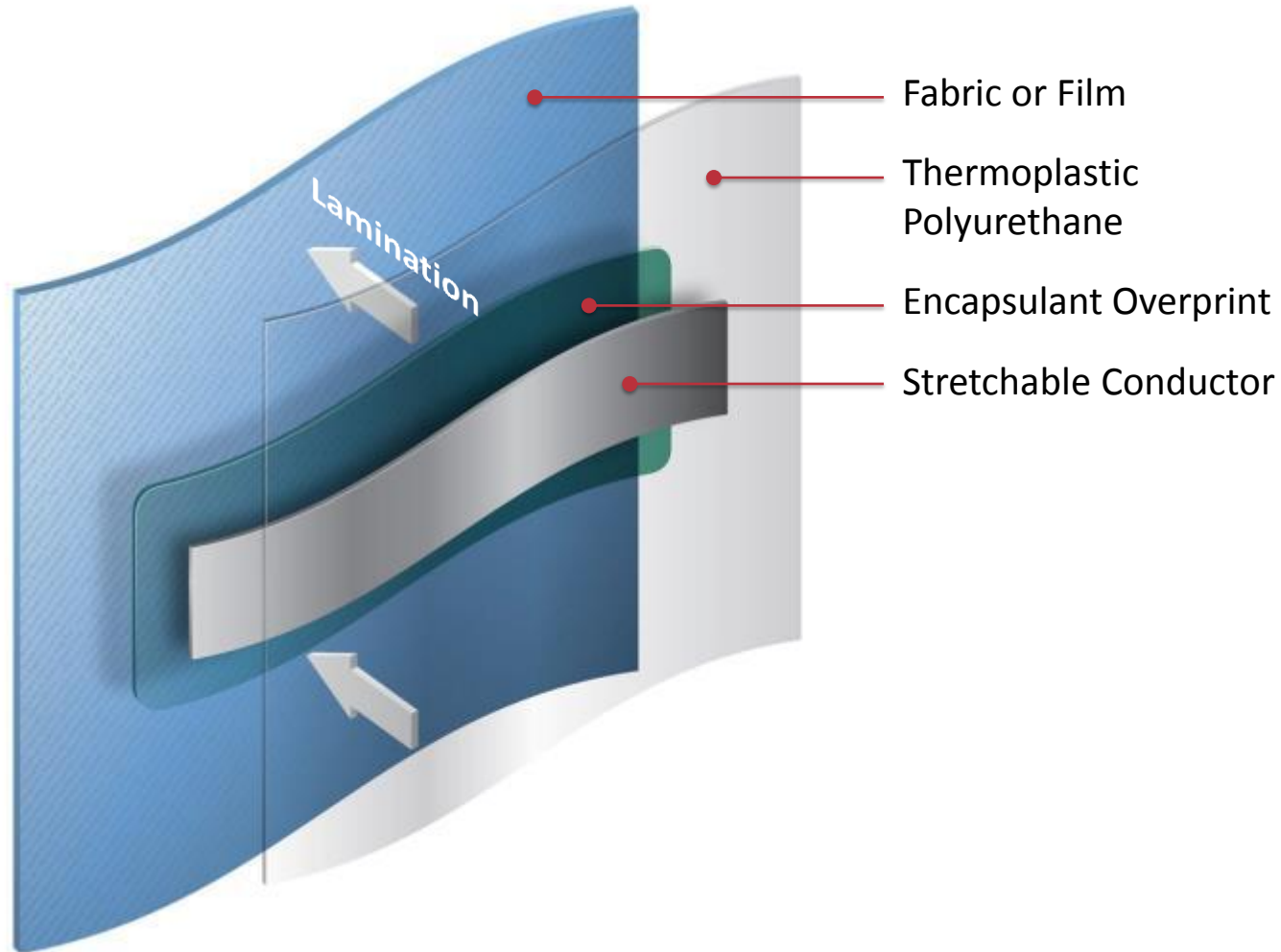
# Lamination Construction Examples

## Printed Sensors



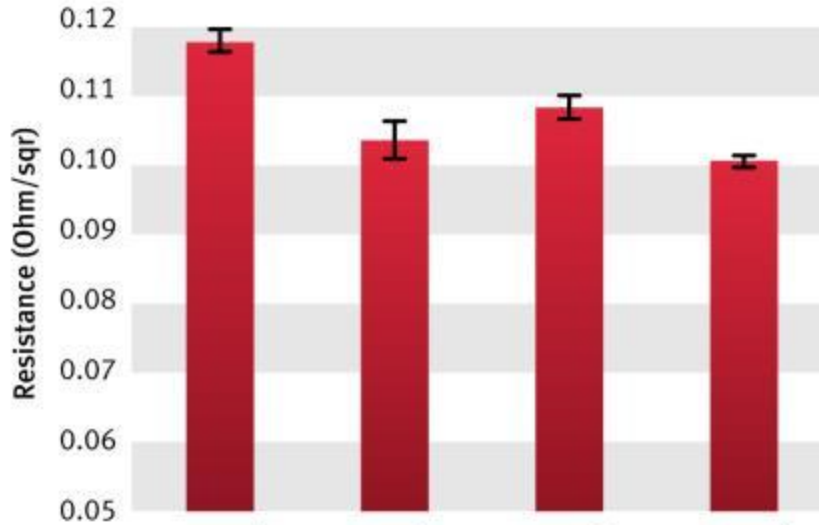
# Lamination Construction Examples

## Printed Conductor Traces





# Conductivity Measurements



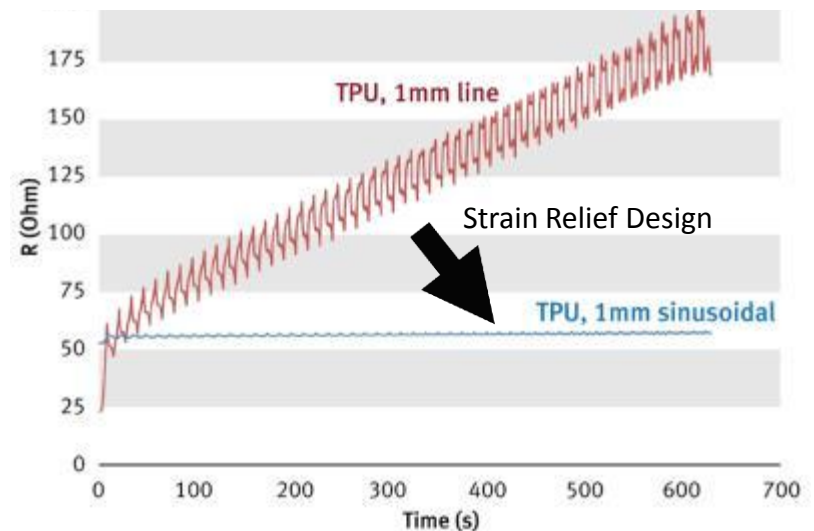
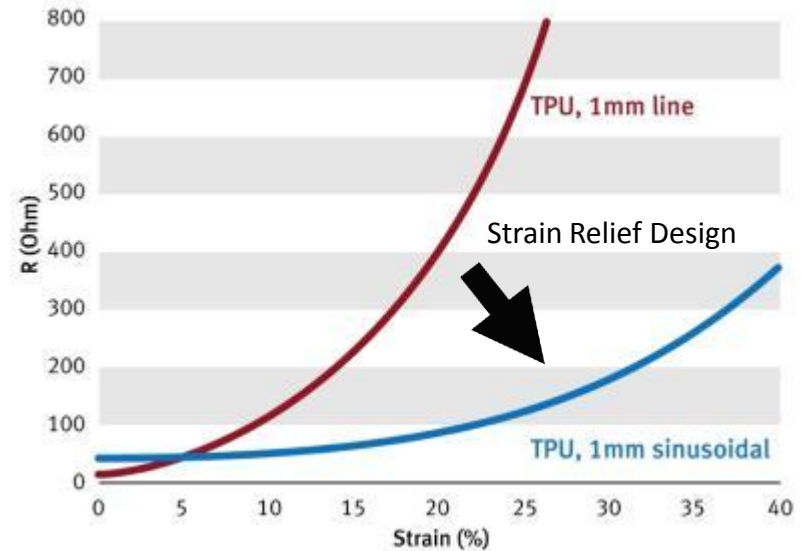
Substrate	TPU	TPU	TPU	Cetus
Ink Layer 1	PE872	PE872	PE872	PE872
Ink Layer 2		Carbon	Ag/AgCl	

- 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



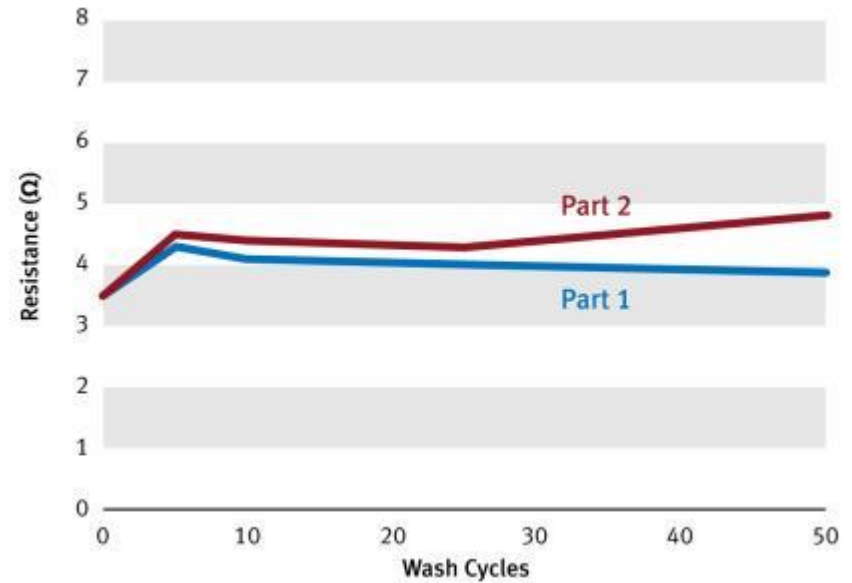
# Stretchability and the Effects of Strain

- 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)



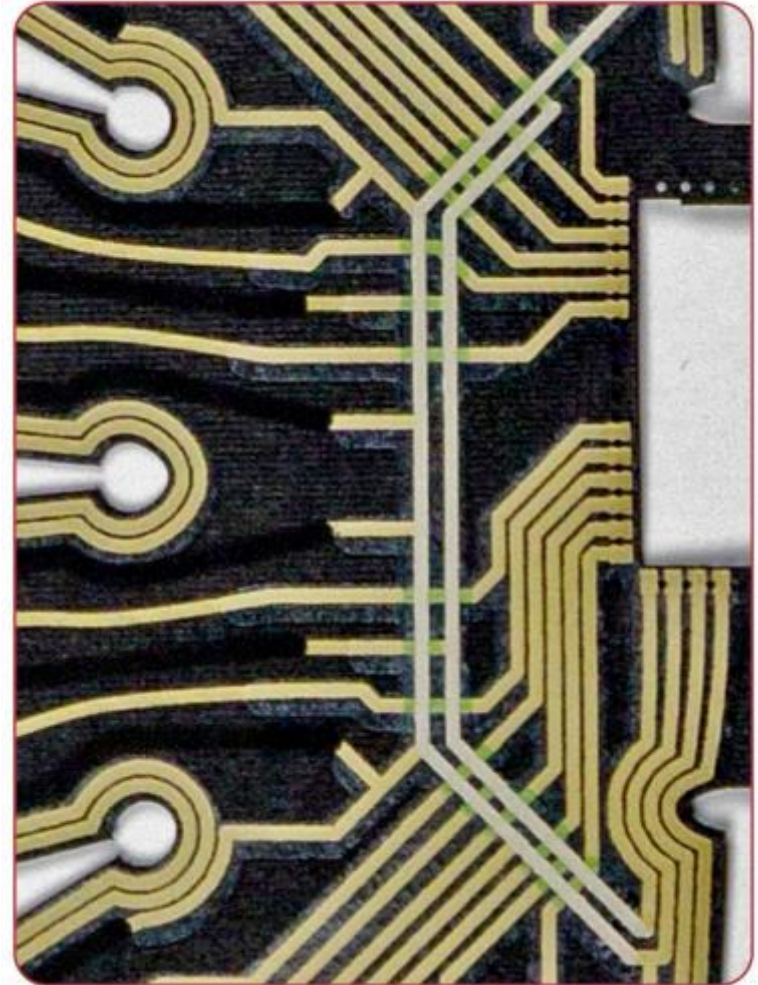
# Washability – Various Solutions Available

- 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.



## 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



Direct print on fabric (image from BeBop Sensors)

## 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



A vibrant, busy street scene in a traditional Chinese market. The street is filled with people, many wearing winter clothing like puffer jackets and knit hats. In the background, there are traditional buildings with red lanterns hanging from the eaves. The overall atmosphere is lively and festive.

WE'RE SOLVING THE WORLD'S GREATEST CHALLENGES

**TOGETHER**

Together we can accomplish  
what no one can do alone.

**WELCOME TO  
THE GLOBAL  
COLLABORATORY**