University of Minnesota Wearable Technology Lab

Surface-Mount Fabrication of Stitched E-Textile Circuits for Garment-Integrated Technologies

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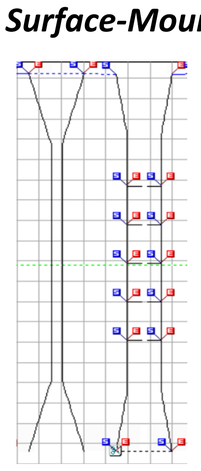
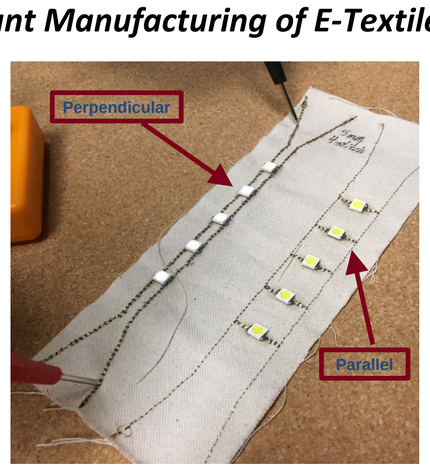
Introduction

The objective of this project is the development of a manufacturing method for electronic textiles where traces and interconnects are stitched to a textile substrate, and surface-mount components are populated using reflow soldering processes. A simulated high-intensity wear test and a long-term launderability test ensured that the method can produce highly durable electronic textiles. Further, we implement the manufacturing technique in an LED matrix display application, a motion responsive visual display shirt, and a sensing garment.

Methods

Surface-Mount Manufacturing of E-Textiles

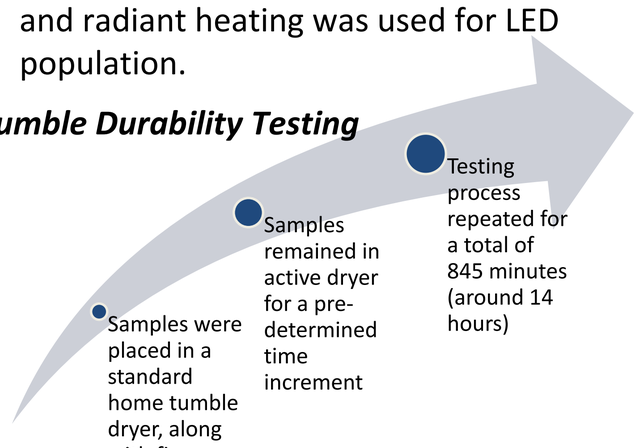




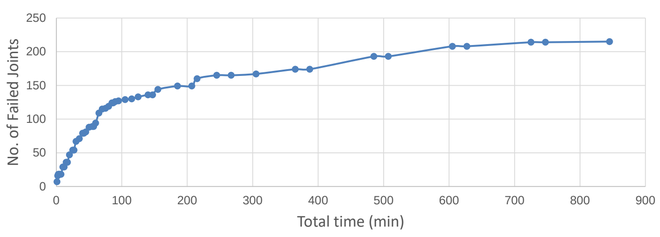
	5mm LEDs	3mm LEDs	1mm LEDs	Total
2 stitch	5	5	5	15
4 stitch	5	5	5	15
6 stitch	5	5	-	10
Total	15	15	10	40

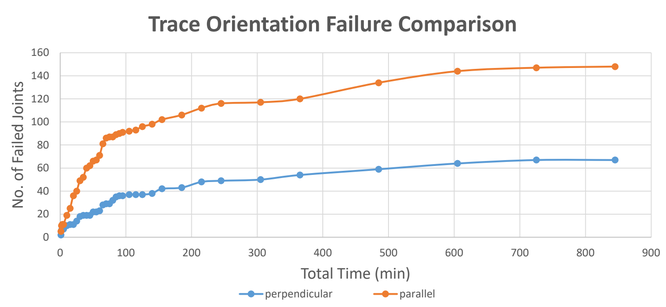
- Solder paste applied manually onto traces and radiant heating was used for LED population.

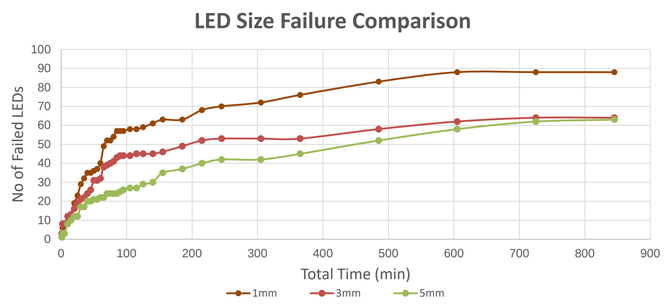
Tumble Durability Testing

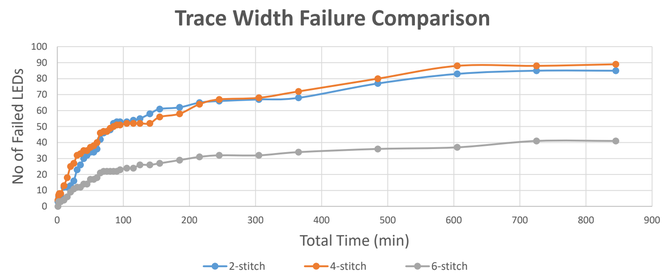


Tumble Durability Testing Results





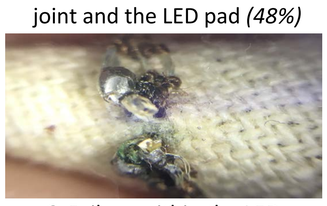




Failure Categorization

A. Failure between the solder joint and the LED pad *(48%)*

B. Failure between the solder joint and the thread trace *(45%)*

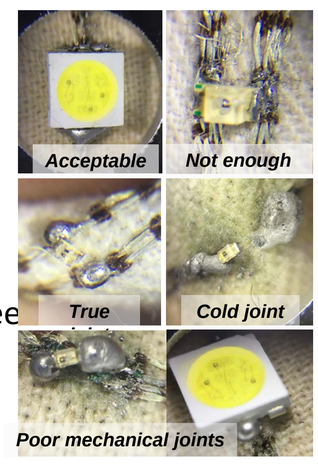


C. Failure within the LED package *(5%)*

D. Failure within the solder joint *(2%)*

Causes of Failure

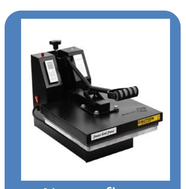
- Variation in the amount of solder
- Quality of joint structure
- Quality of the mechanical connection between LED & solder and solder & thread



Method Refinement

Manual application of solder and heat-gun reflow

Solder stencil and oven-based reflow

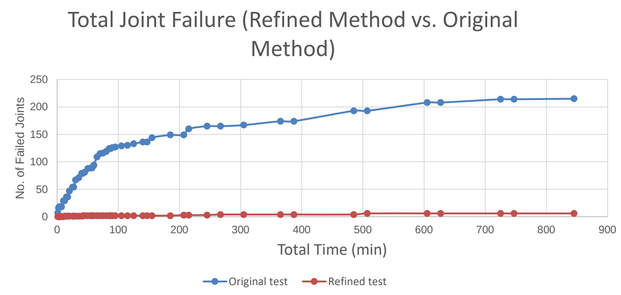


New reflow technique using a PowerPress industrial plate heat press

	5mm LEDs	3mm LEDs	Total
2 stitch	10	10	20

- Low-melt solder paste mixed along with equal amount of gel flux and direct contact heating method was used.
- Samples were tested using a tumble dryer for 14 hours.

Refined Method Results



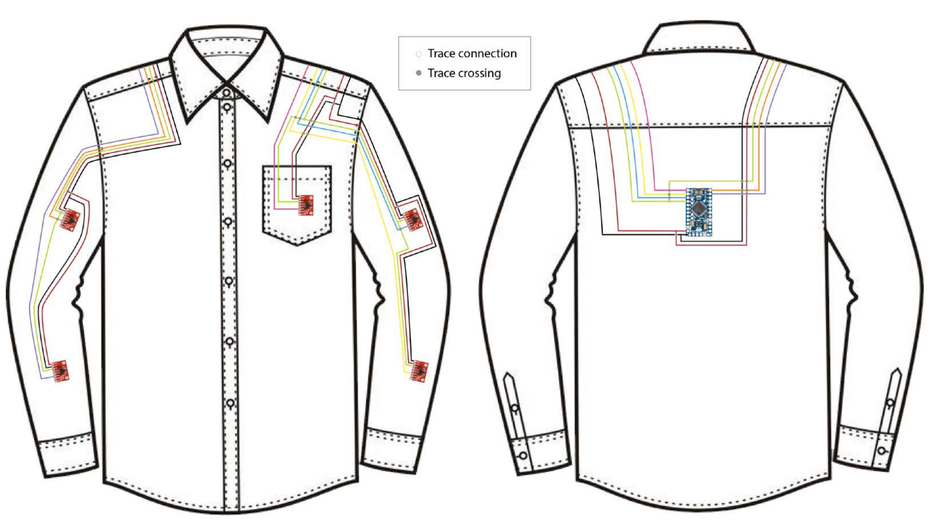
- The failure rate reduced to 3% from 26%.
- Poor mechanical connection was identified as the main reason for the failures.

Launderability of E-Textiles

- After around 17 hours of rigorous washing and drying, measured a 1.5% failure rate for component solder joints.

LED Matrix and A Motion Responsive Visual Display Shirt

Current work: A Sensing Garment



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