WCP-43 ROLL TO ROLL IN LINE DEFECT DETECTION

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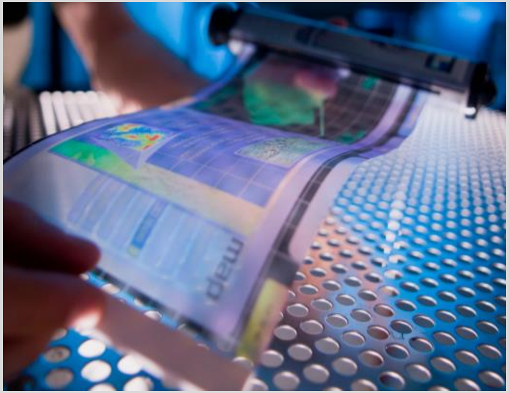
BINGHAMTON UNIVERSITY | THOMAS J. WATSON SCHOOL OF ENGINEERING AND APPLIED SCIENCE

PROBLEM DEFINITION

To detect for defects upon thin film substrates through the use of an in line defect detection system for roll to roll manufacturing



THE TEAM

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AGENDA

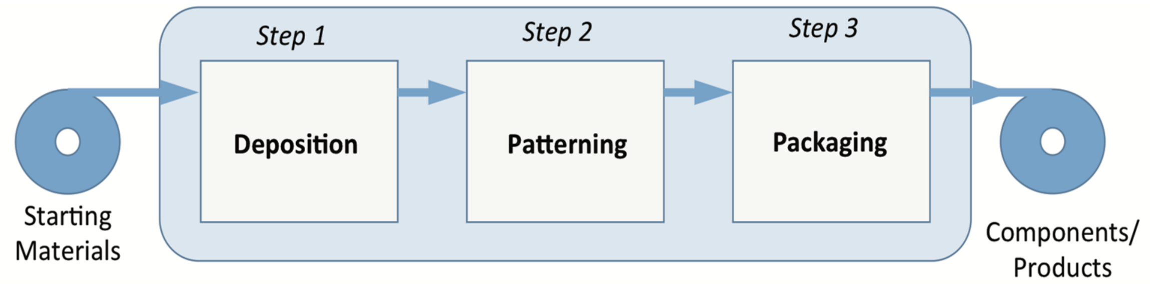
- Background
- Problem Overview
- Requirements
- Design and Implementation
- Conclusions

BACKGROUND

ROLL TO ROLL MANUFACTURING

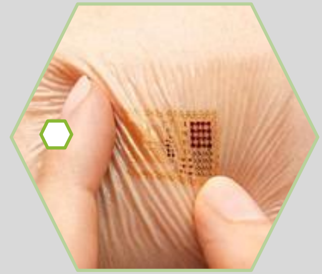
- Roll to Roll refers to a style of manufacturing of thin flexible films
- Common materials are:

Polyimide PET Glass Ceramics

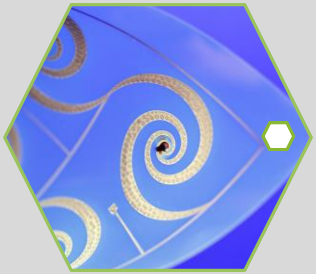


Adapted from A. Gregg, L. York, and Mark Strnad, “Roll-to-Roll Manufacturing of Flexible Displays,” in G.P. Crawford (ed.), Flexible Flat Panel Displays, Wiley, 2005.

THIN FILM TECHNOLOGY APPLICATIONS



Wearable technology



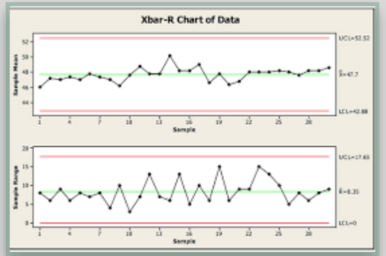
Large flexible displays

Photovoltaics

Chernova, Y. (2012, December 19). Are Wearable Flexible Electronics the Next Big Thing? MC10 Says So. Retrieved from https://blogs.wsj.com/venturecapital/2012/12/17/are-wearable-flexible-electronics-the-next-big-thing-mc10-says-so/

IN-LINE DEFECT DETECTION: WHY IS IT CRITICAL?

QUALITY FACTOR

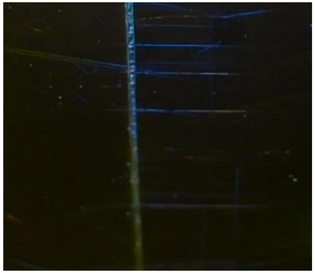


SPECIFICATIONS

VARIETY OF DEFECTS

VARIETIES OF DEFECTS

Contaminates



Scratches

Continuous,
Repeating,
Needles,
Pinpoint,
Scuffs

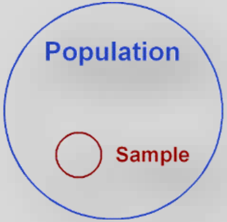
Internal material flaw

SPECIFICATIONS EXAMPLES

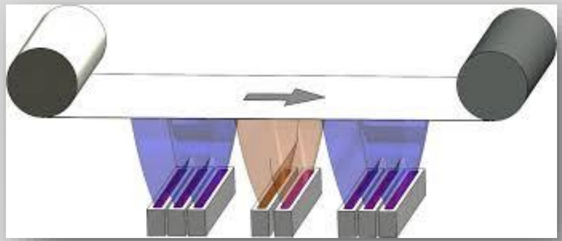
Specifications can be defined by length or by density

	Density of Scratches on web		
	Low (<20 scratches / m^2)	Medium (20-100 scratches / m^2)	High (>100 scratches / m^2)
Scratches (Level 1: Continuous)	FAIL	FAIL	FAIL
Scratches (Level 2: > 5 mm in length)	FAIL	FAIL	FAIL
Scratches (Level 3: 1-5 mm in length)	PASS	PASS	PASS
Scratches (Level 4: < 1 mm in length)	PASS	PASS	PASS

PROFESSIONAL OUTREACH- DUPONT TEIJIN FILMS



No Sampling



In-line Defect Detection System

Defects Found

PROJECT OVERVIEW

PROJECT OBJECTIVE

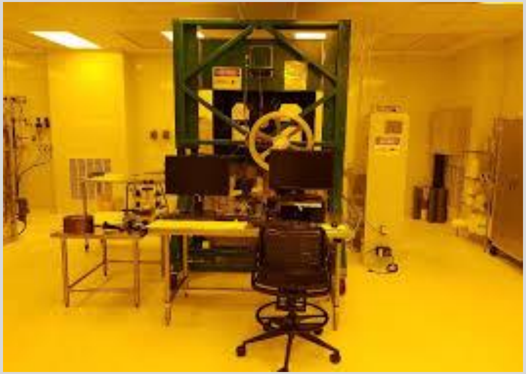
To inspect and establish quality of thin film substrates

Integrate new system with the existing system

Detect defects

MAJOR REQUIREMENTS

The system shall build off previous year's work



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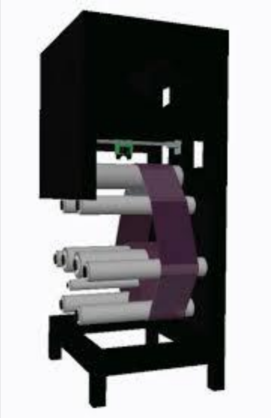
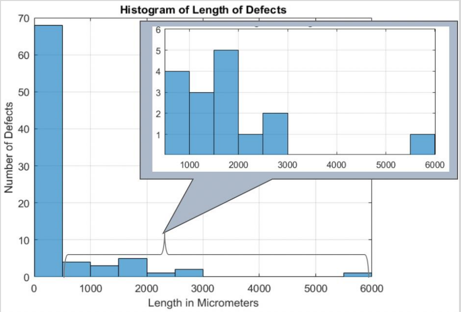
MAJOR REQUIREMENTS

The system shall detect defects on thin films processed through the system



MAJOR REQUIREMENTS

The system shall output the data in a readable format



PLANNING

MATLAB Code: Version 2 → Scratches vs. Dust → Sampling → Testing → Redesign

DESIGN CHALLENGES

Green LED light on sensor

Image clarity

Sensor was not secure

Sensor had to be sent to Gang for fixing. Only $ this year

Verification of intentionally modified samples

Utilization of various sensors

RISK MANAGEMENT

Physical Safety

- Safe lab attire
- Follow procedures

Equipment and Technology

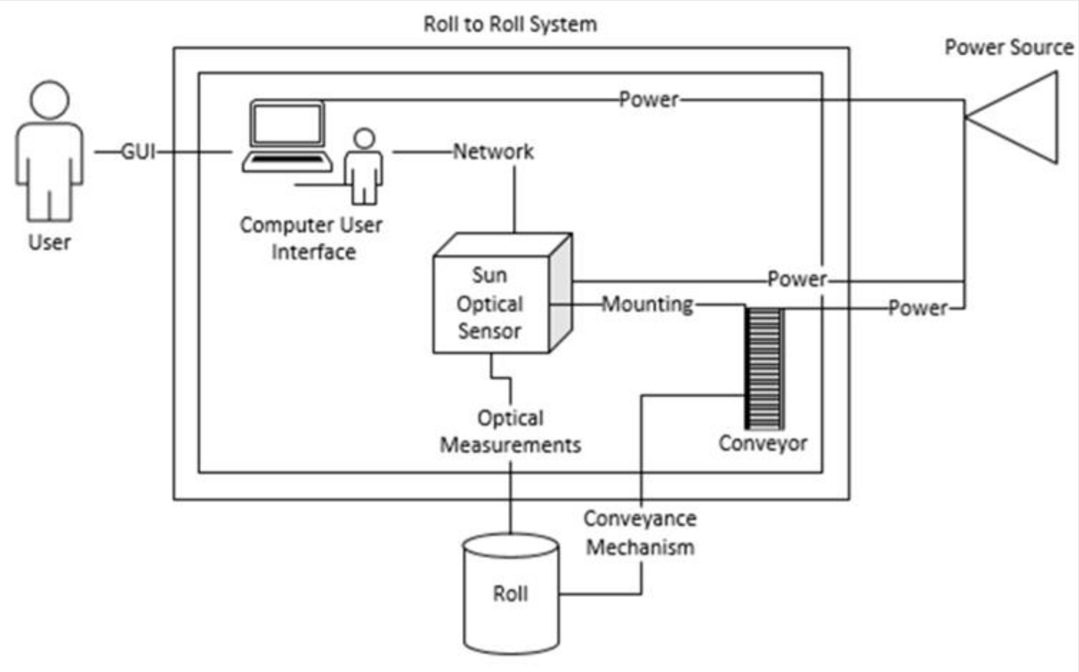
- Properly handling
- Frequently backup & save code

Industry Risks

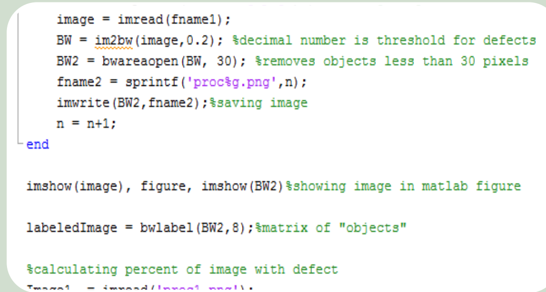
- Prevent Type II Errors
- Keep roll integrity
- Prevent loss of money

DESIGN AND IMPLEMENTATION

SYSTEM DIAGRAM



EQUIPMENT


```
    image = imread(fname1);
    BW = im2bw(image,0.2); %decimal number is threshold for defects
    BW2 = bwareaopen(BW, 30); %removes objects less than 30 pixels
    fname2 = sprintf('proc%g.png',n);
    imwrite(BW2,fname2);%saving image
    n = n+1;
end

imshow(image), figure, imshow(BW2)%showing image in matlab figure

labeledImage = bwlabel(BW2,8);%matrix of "objects"

%calculating percent of image with defect
```

Hardware

- Roll to Roll Inspection Platform
- SunOptical Defect Sensor
- Raspberry Pi Interface

Software

- MATLAB Code
- Python Program

SENSOR

SunOptical Defect Sensor Created by Gang Sun

Captures high resolution images of roll at the same rate as the roll speed

Uses 4 adjustable RGB lights to highlight roll defects

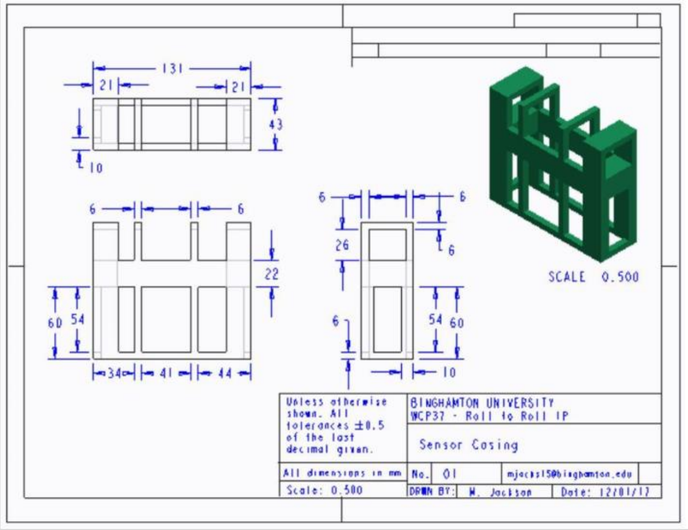
Uses a Raspberry Pi and communicates with Windows machine via Ethernet

VIBRATIONS CONTROL

Mount not to be redesigned

Mount uses friction to hold sensor in place

Later drilled holes for set screws to keep sensor in place



VIBRATIONS

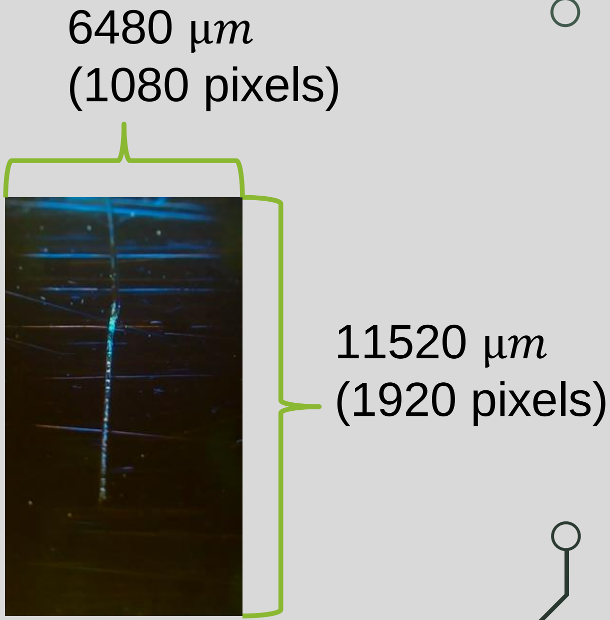
- Data acquired with Vernier 3-Axis Accelerometer
- Accuracy of +/- 0.5 m/s^2
- Minimal vibration

PIXEL CONVERSION

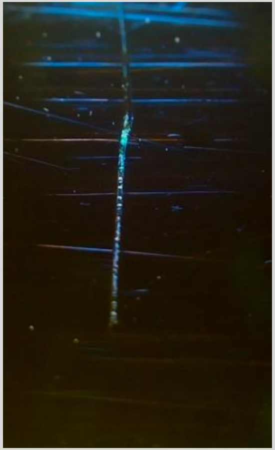
To determine sizes of defects the size of pixels must be calculated for the sensor position

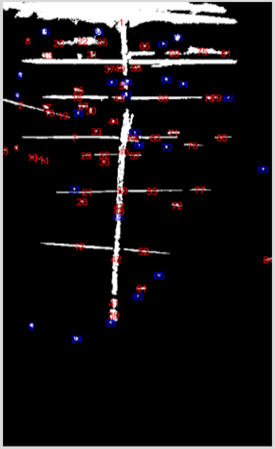
$$\frac{6480\mu m}{1080\ pixels} = 6\mu m\ per\ pixel$$

Pixels are $6\mu m$ x $6\mu m$



MATLAB PROCESS

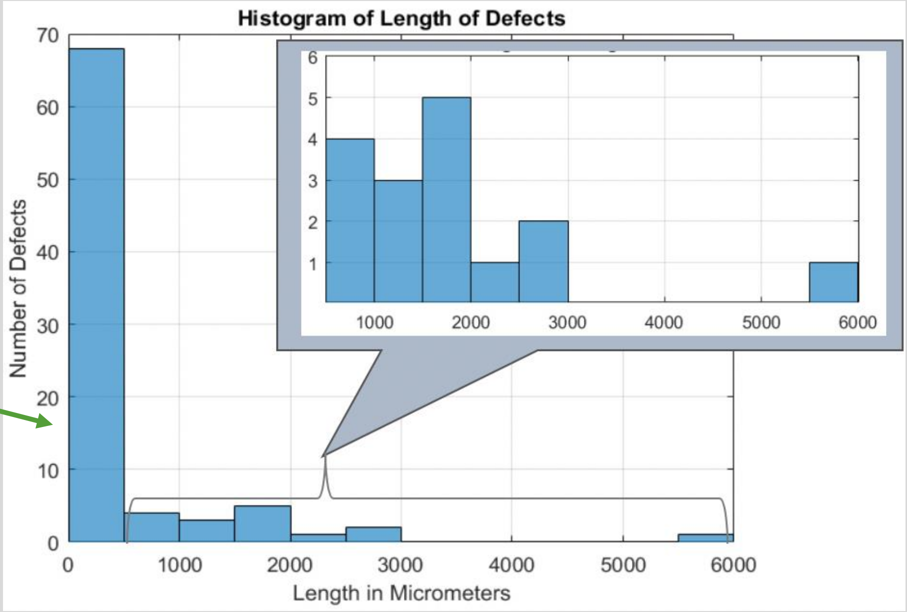




Original Image → Binary Image → Labeled Image

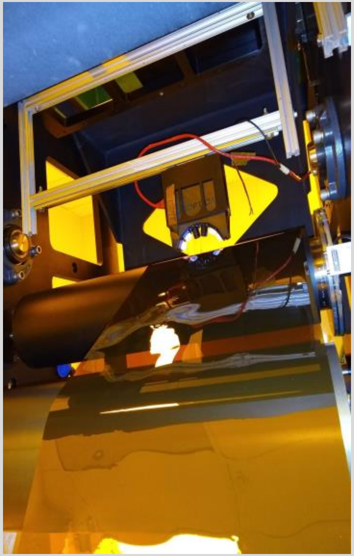
DATA OUTPUT

Smaller particles are more likely contaminates



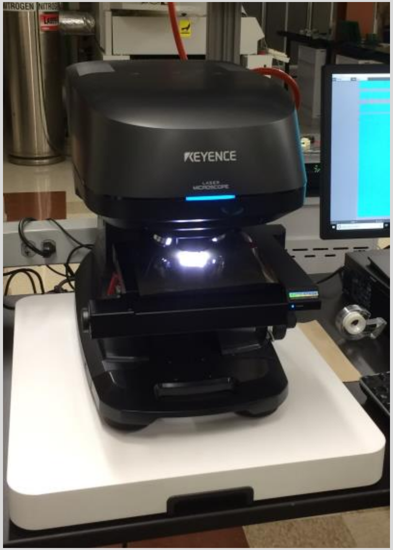
EXPERIMENT

- Run Polyimide film under sensor
- Identify defects from film
- Compiled to form our data pool
- Verify defects using Keyence Microscope

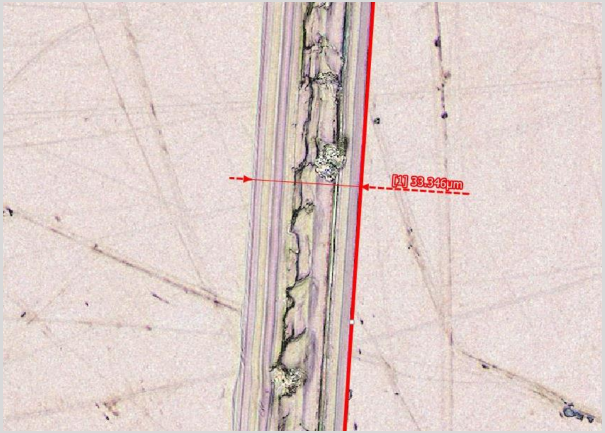


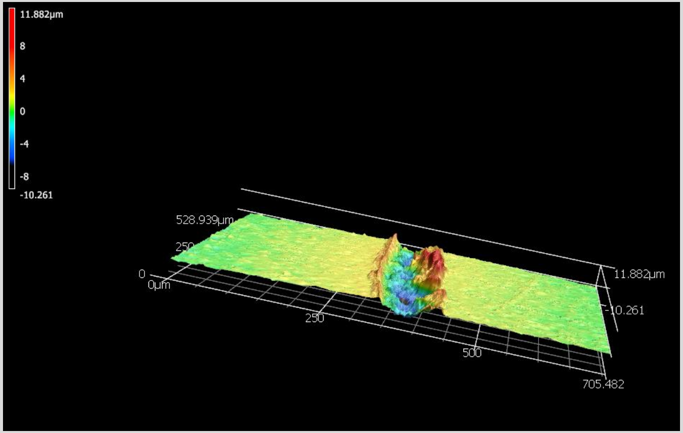
VERIFICATION

- Used Keyence Confocal Microscope at SEML at ITC
- Determine major and minor axis length for scratch samples
- Photos take are at a range of 2.5X magnification to 50X



KEYENCE CAPABILITIES





SUMMARY

- Tested vibrations on sensor mounting
- Created MATLAB code that can detect defects
- Gathered data from the CAMM lab using the sensor
- Data can be verified using Keyence Microscope

FINAL STATEMENTS

CONCLUSION

Detection of defects upon thin film substrates → Screen for quality of thin film substrates → Satisfied customers

FUTURE PLANS

LIGHT INTENSITY

Reflected light intensity can also detect defects

SAMPLING VERIFICATION & VALIDATION

Produce exaggerated scratches for verification

FRAME STITCHING

Stitch the multiple sample images together

ALTERNATIVE LENS

Use the FPGA lens on SunOptical sensor

ACKNOWLEDGEMENTS

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Dr. Mark Poliks, Faculty Advisor

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THANK YOU! ANY QUESTIONS?