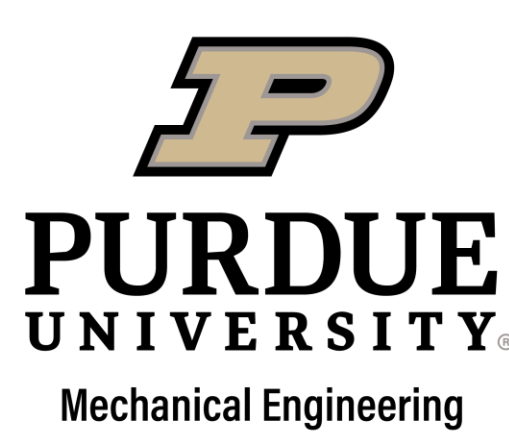


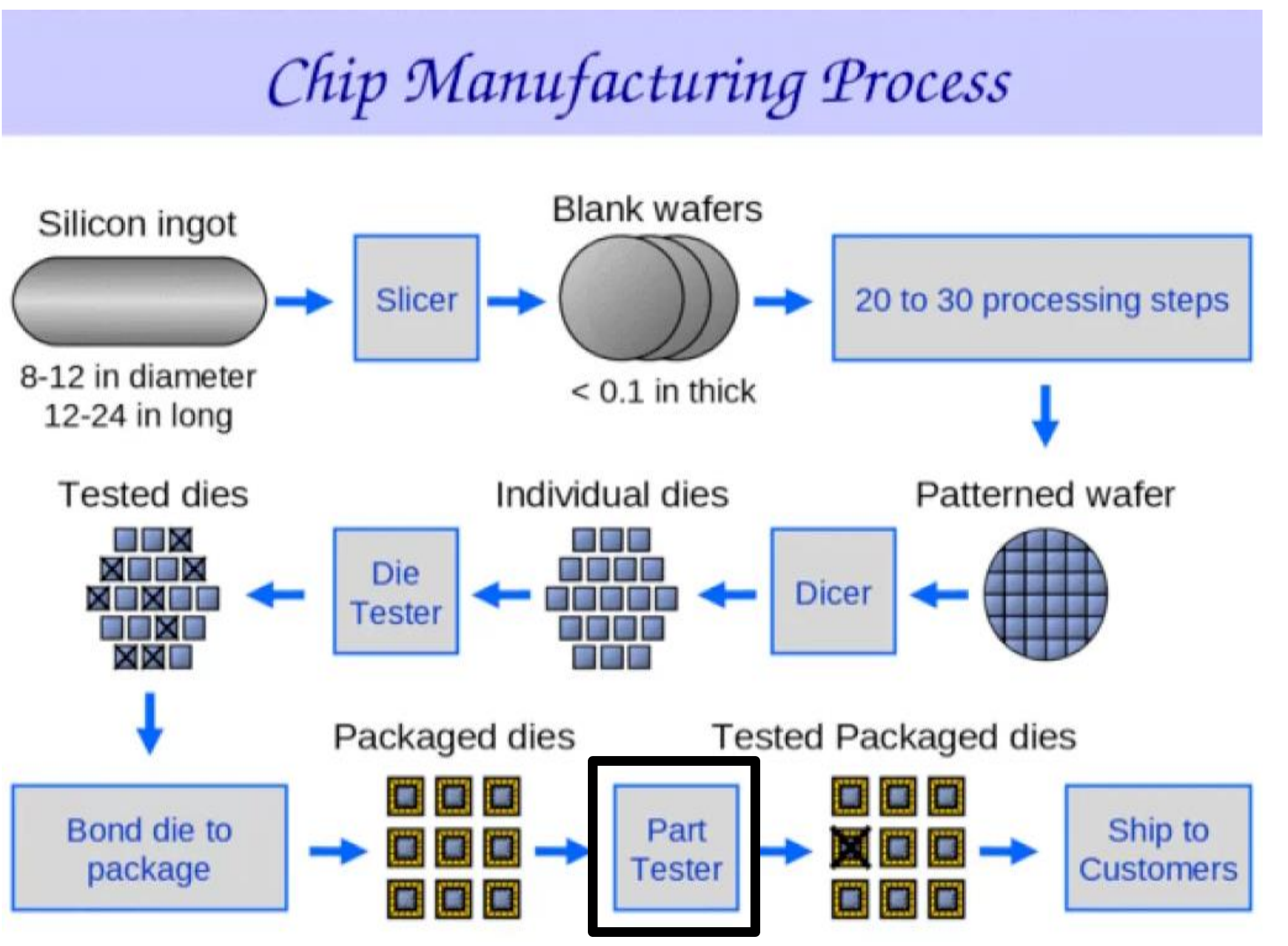
SCS Solutions Hot Spot Detector for Semiconductors




Overview

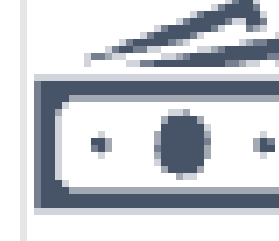
During semiconductor chip production, incidental defects develop hot spots which are locations of high thermal flux. Hot spots beget extreme temperatures that decrease product reliability. SCS Solutions presents an automated hot spot detection device which is cost-competitive and requires minimal interaction.

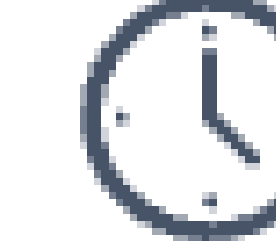
Semiconductor Mfg.




Customer Requirements

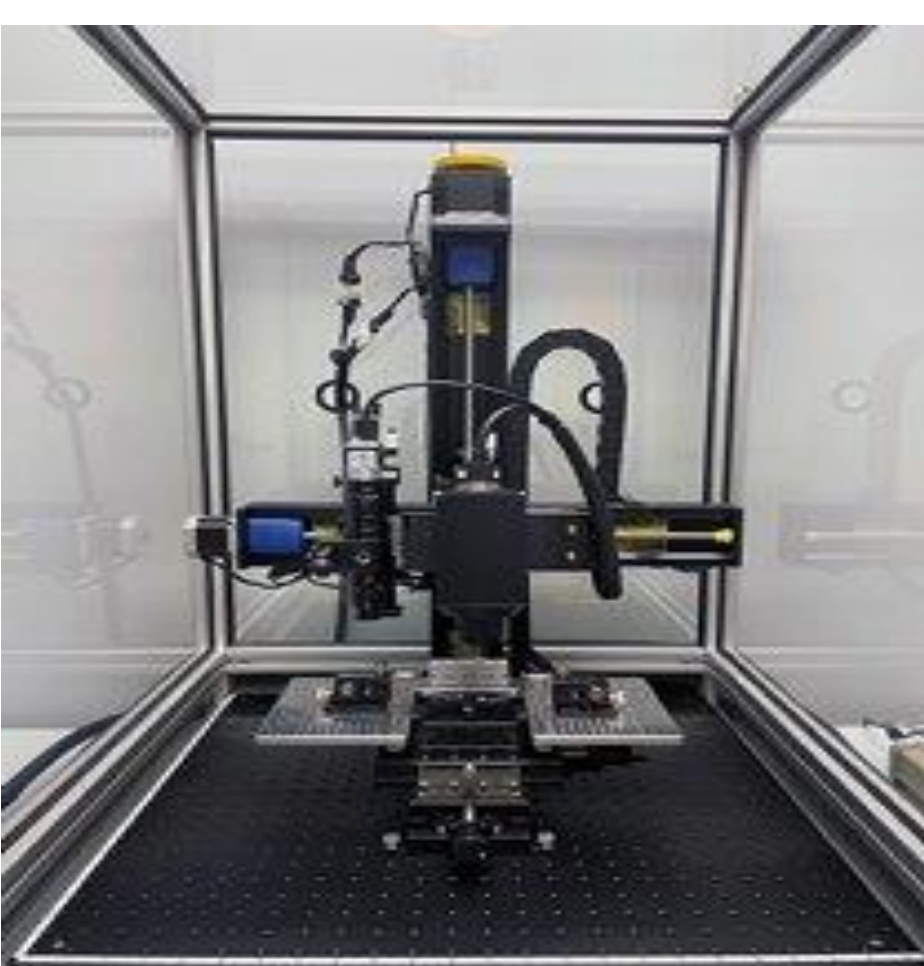
**Accuracy**

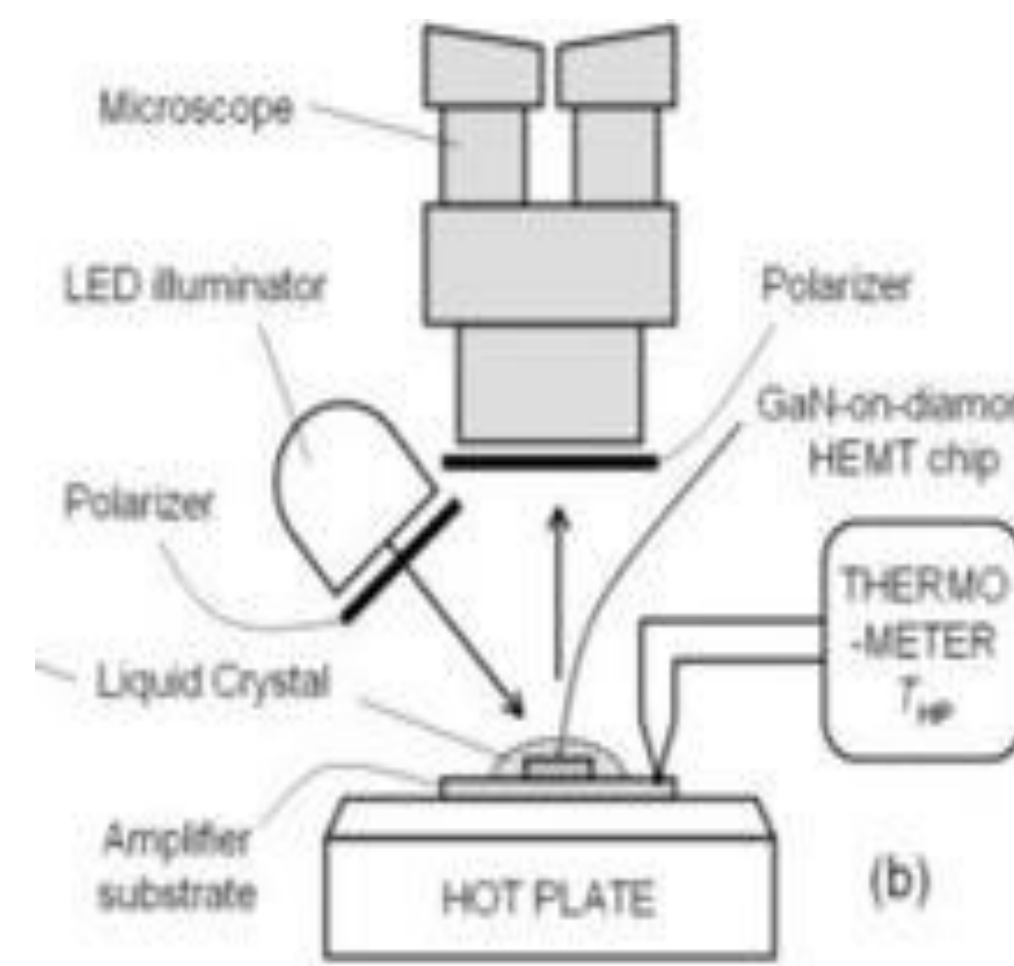
**Low Cost**

**Time of Test**

**Maintenance**

Competitors

Ophtho therm Sentris

Price: ~ \$10,000

Liquid Crystal Solution

Price: \$8700+

Value Proposition

Bottom-Up Analysis (For a 5-year period):

32,108 Chip Fabs

32,108 Potential Sales

1600 Sales

High Barriers to Entry

5% Market Capture

Forecasted Revenue – **\$5.76M**

Forecasted Profit – **\$1.70M**

Societal Benefit:

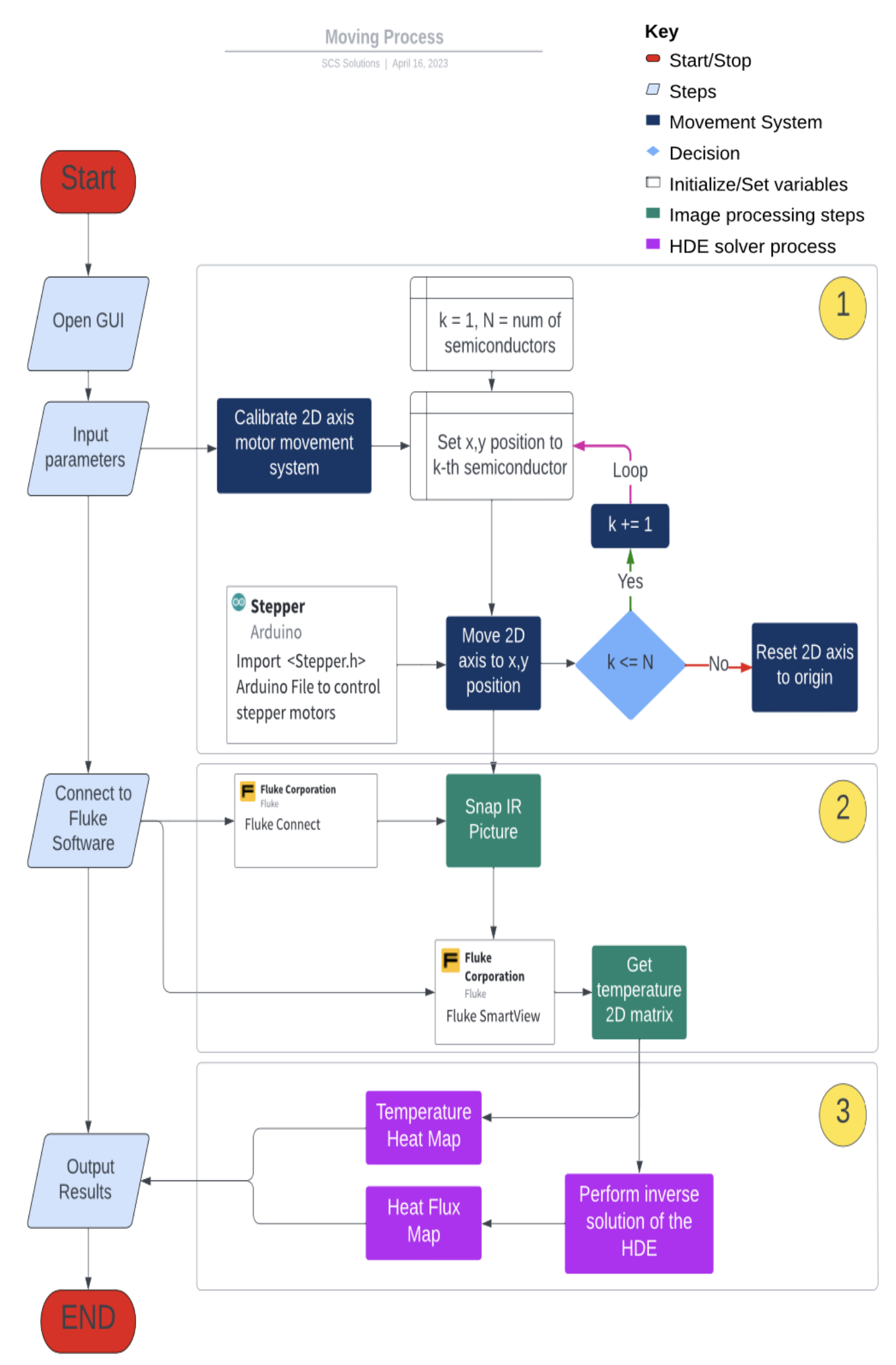
↑ in chipset reliability

↓ in material waste (vs. liquid crystal)

Product Design and Analysis



- Mechanical & Electrical Design:**
- (1) Superstructure: Supports movement system, camera, electronics bays
 - (2) 2D Movement System: 3 motors actuate camera over any location
 - (3) Electronics Bay: Holds chip samples & necessary control equipment
- Control Design:**
- (1) Input sample locations
 - (2) Actuates to location, snap photo
 - (3) Analyze 2D temperature matrix to produce 2D heat flux matrix



Heat Diffusion Equation

$$-q'' = \frac{k}{dz} \left(\frac{d^2T}{dx^2} + \frac{d^2T}{dy^2} \right)$$

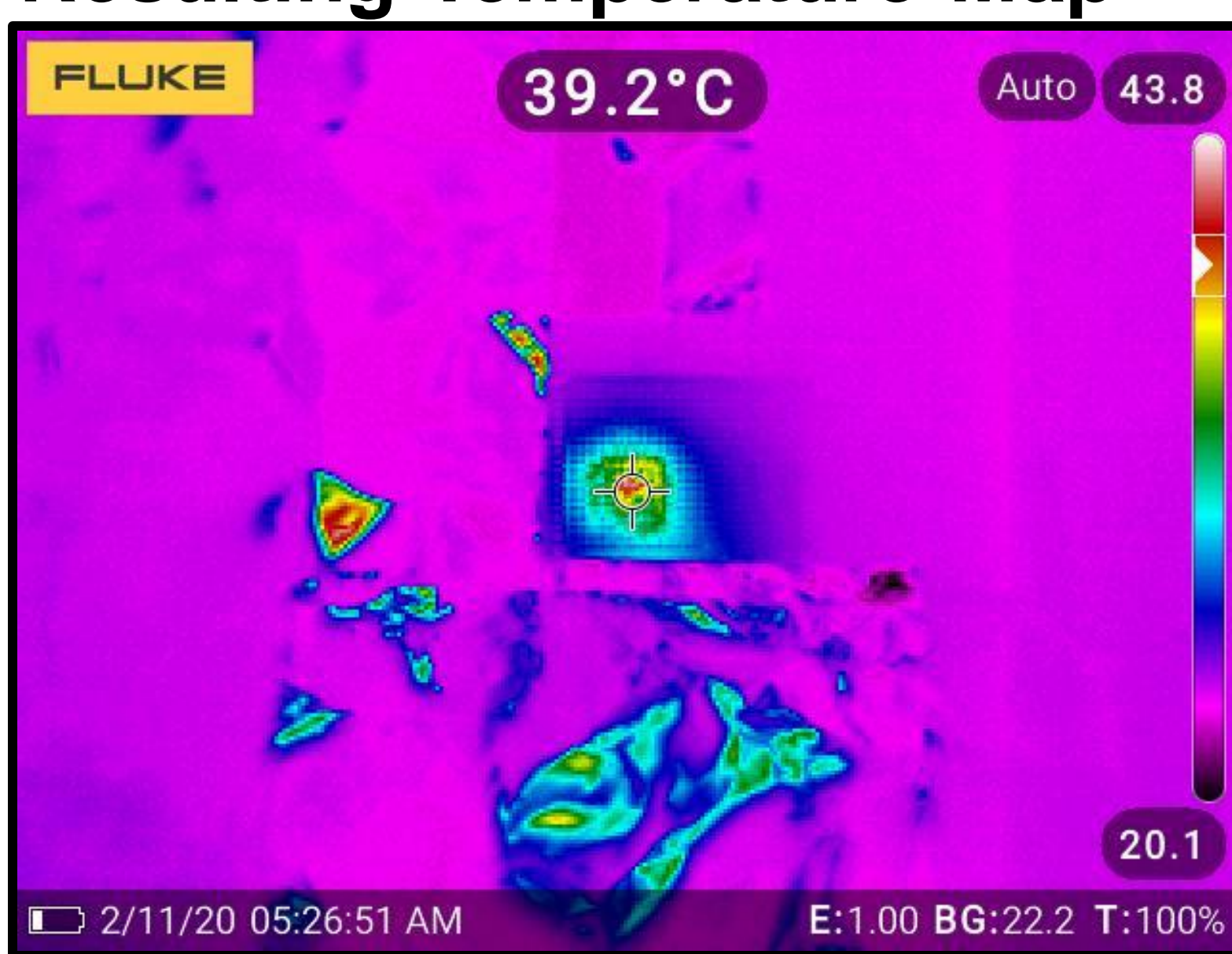
Key Assumptions: (1) Steady State (2) Isentropic (3) 2D heat conduction

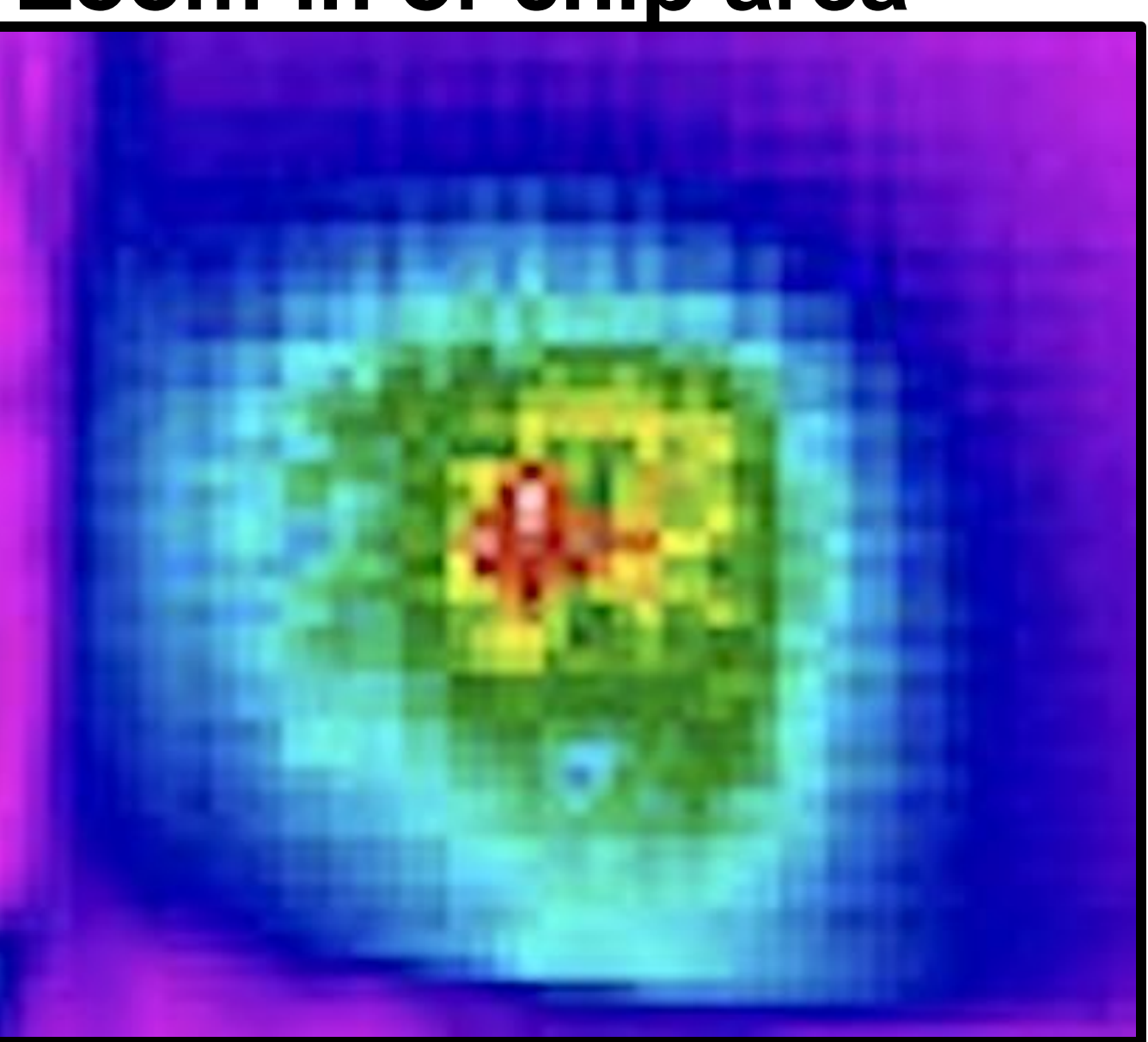
Variables: q'' , k , T

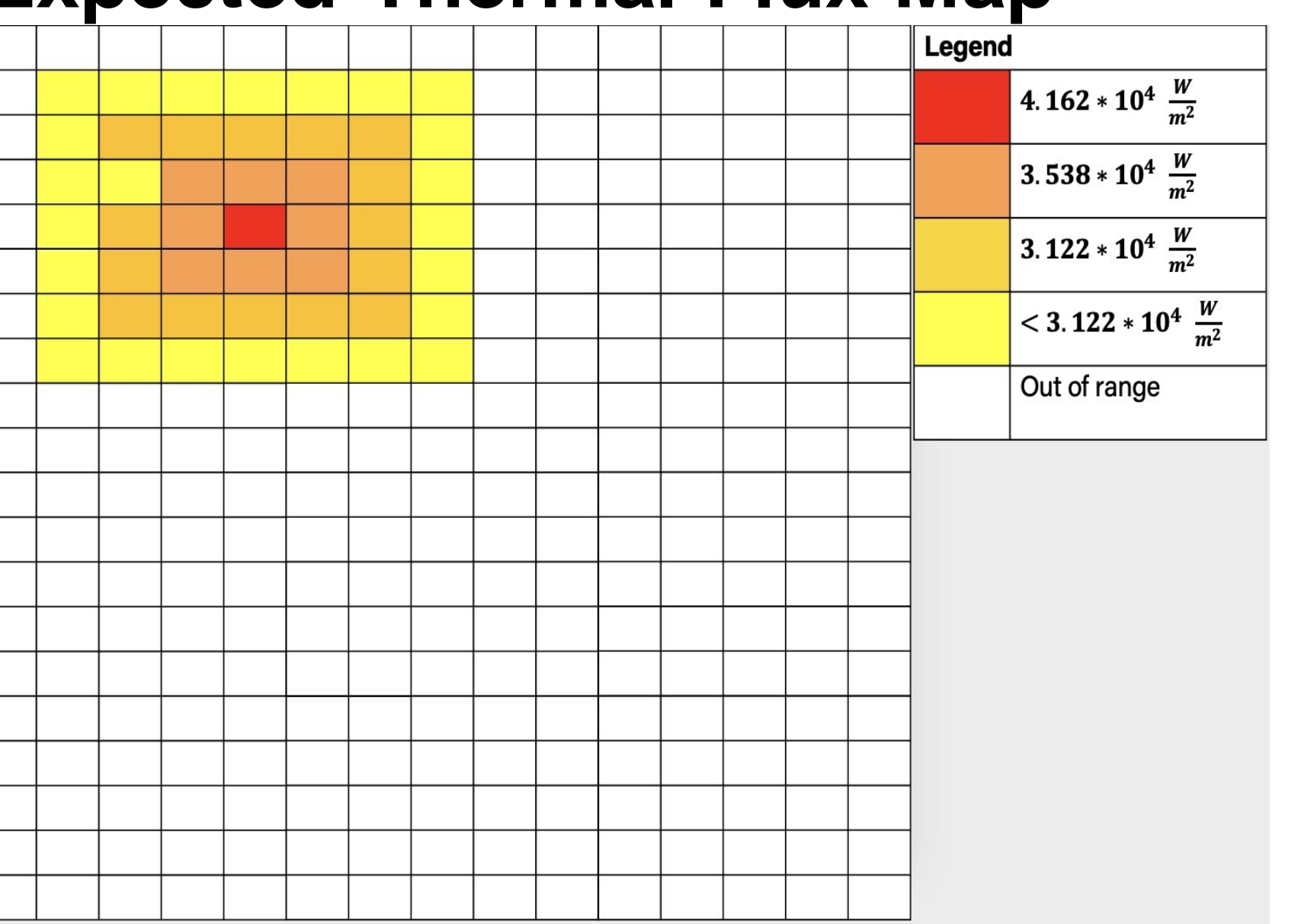
Q is the heat flux; T is temperature measured

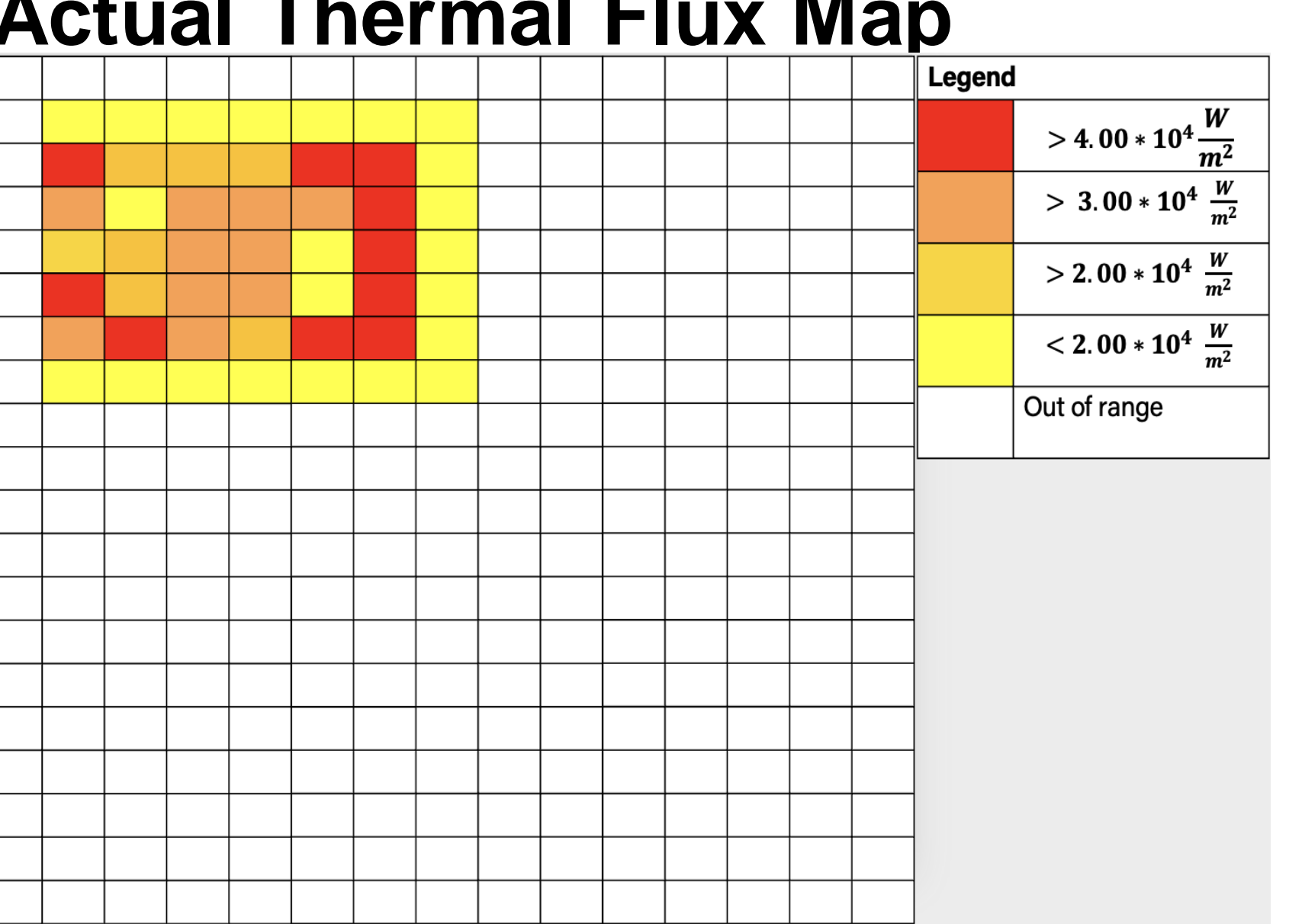
k is the average thermal conductivity of the resistors/solder

Results

Resulting Temperature Map


Zoom in of chip area


Expected Thermal Flux Map


Actual Thermal Flux Map


Statistics (Results vs. Expected):

- (1) 88% of hot spot locations detected ($\pm 1 \cdot 10^4 \text{ W/m}^2$ of expected)
- (2) False positive rate of 26.32% ($> \pm 1 \cdot 10^4 \text{ W/m}^2$ of expected)

Discussion: An inverse solution to the HDE develops a thermal flux map from raw temperature data. The implemented solution fits a 2nd order polynomial fit for each row ($T(x)$) and for each column ($T(y)$). The second derivative of each fit serves as input for the simplified HDE above.

Operation Procedure

1. Load samples onto acrylic raised plate & apply location inputs to program interface
2. Run program and review results
3. Replace verified chips back onto the production line

Performance Comp.

Req.	SCS	Sentris	Liquid Crystal
Accuracy (Desired: $\pm 2.5^\circ\text{C}$)	$\pm 2^\circ\text{C}$	$\pm 2^\circ\text{C}$	$\pm 1^\circ\text{C}$
Test Time (Desired: < 10 mins)	3 mins / <9 chips	5 mins / chip	1 mins / chip
Costs (Desired: < \$5000)	\$3600	~\$10,000	~\$8700 (10,000 single uses)
Maintenance (Desired: 100,000 cycles)	100,000 cycles	100,000 cycles	N/A: Excess waste and runoff

Potential Improvements

1. Improve analysis model to account for transience of heat input
2. Integrate the detector into an assembly line
3. Investigate the performance of higher resolution IR cameras with differing focal lengths, lenses, and other criteria

Contributors

SCS Solutions would like to thank Dr. Devahdhanush for his guidance and support throughout the project.