



ACCELERATING  
INNOVATION

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## Removing Excess Heat from Ungrounded Surface Mount Devices

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# Thermal Bridges

## Outline

- **Introduction**
  - Heat Pipes Background
- **Baseline Tests**
- **Design Optimization**
  - Via Density
  - Heat Pipe Size
- **Optimized Performance**

# Thermal Bridges

## Introduction – About Me

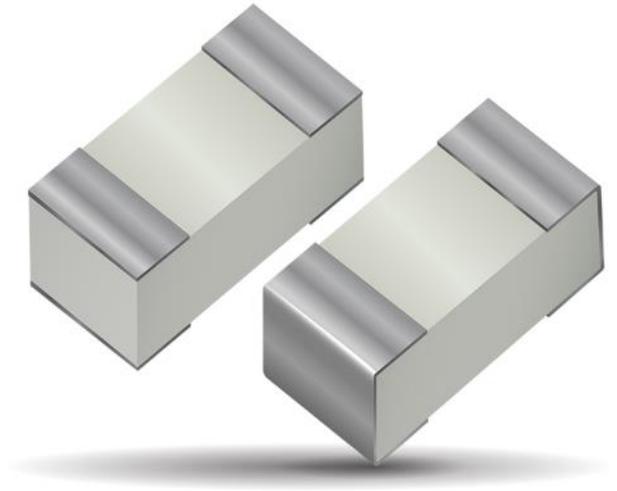
- **Cory Nelson**
- **Principal Design Engineer**
  - Thin Film Components
  - Multi-Layer Organic (MLO) Products
- **KYOCERA AVX for 7 years**
  - Previously at Collins Aerospace and Honeywell
- **Masters of Science from Iowa State University**
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# Thermal Bridges

## Introduction – Heat Pipe Background

- **Electrical components generate heat**
- **Ungrounded components radiate heat with no path**
- **Heat pipes remove the excess heat**
  - Electrically isolated, thermally conductive
  - Surface mountable components
  - Move heat from isolated components to a heat sync or ground
- **For this study the KYOCERA AVX Q Bridge product was used**
- **Reduce heat from a hot spot of board or extend power range of existing product!**



# Thermal Bridges

## Baseline Tests

- **Using a 2010 1kΩ Resistor as a stand alone component**
  - Applied power to get temperature responses
  - Record max power at part temperature of 125°C – 841mW
- **Added thermal pad same size**
  - Equivalent board space as Q Bridge
  - Applied power to get temperature responses
- **Used a 2010 Q Bridge component**
  - Applied power to get temperature responses

Reduction of max temperature by 45 °C with Q Bridge!

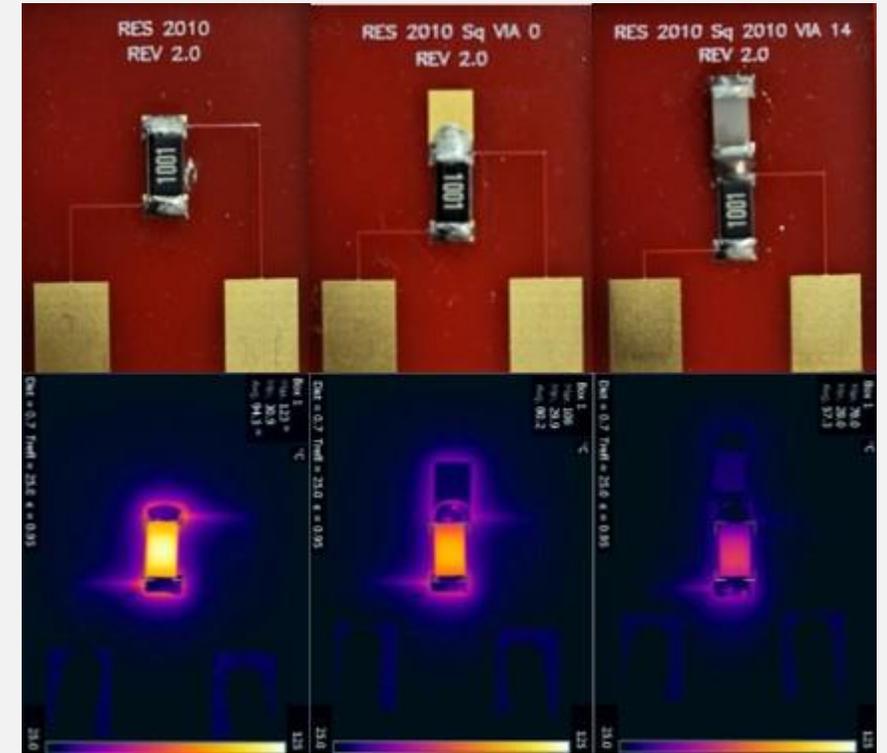
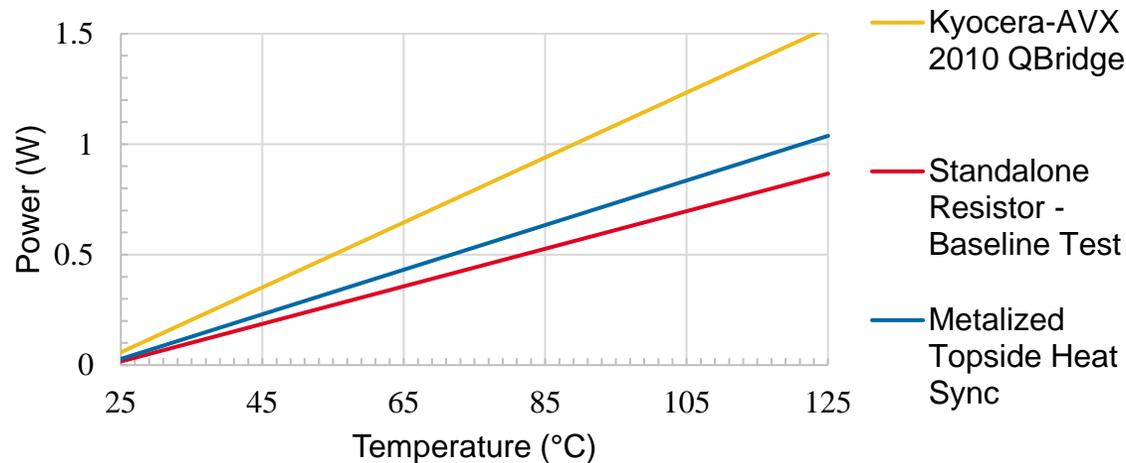
Thermal Management	Component Power at 125°C	Temperature at 841mW
No thermal management	0.84 W	123°C
Metal thermal pad	1.04 W	106°C
Q-Bridge ceramic heat bridge	1.53 W	78°C

# Thermal Bridges

## Baseline Tests - Results

- Thermal bridges help remove heat from ungrounded components
  - Improves power handling as well
  - Improvement over traditional metalized thermal pads

Power vs Temperature of Standalone Resistor, Metal Heat Sink, and EIA 2010 Q Bridge

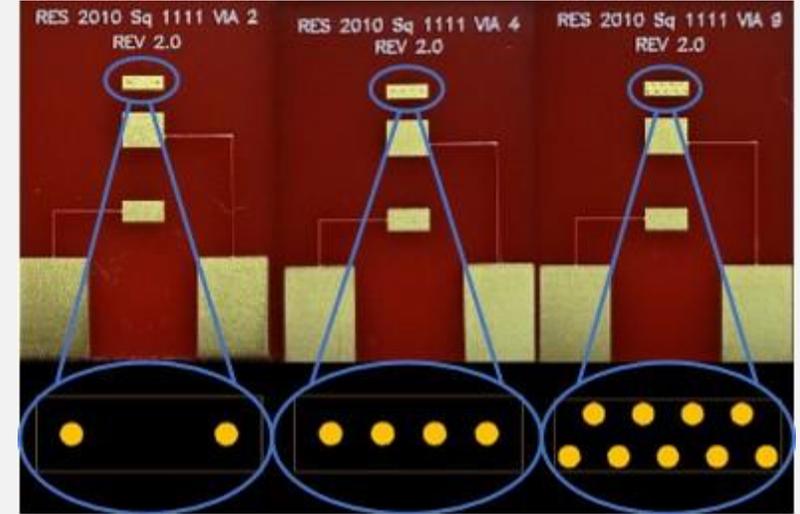


**Top Left** Standalone resistor on test board without heat mitigation; **Bottom Left** Standalone resistor with 841mW applied; **Top Middle** Standalone resistor on test board with surface metal heat sync; **Bottom Middle** Resistor with surface heat sync with 841mW applied; **Top Right** Resistor with 2010 ceramic heat bridge; **Bottom Right** Resistor with 2010 ceramic heat bridge with 841mW applied.

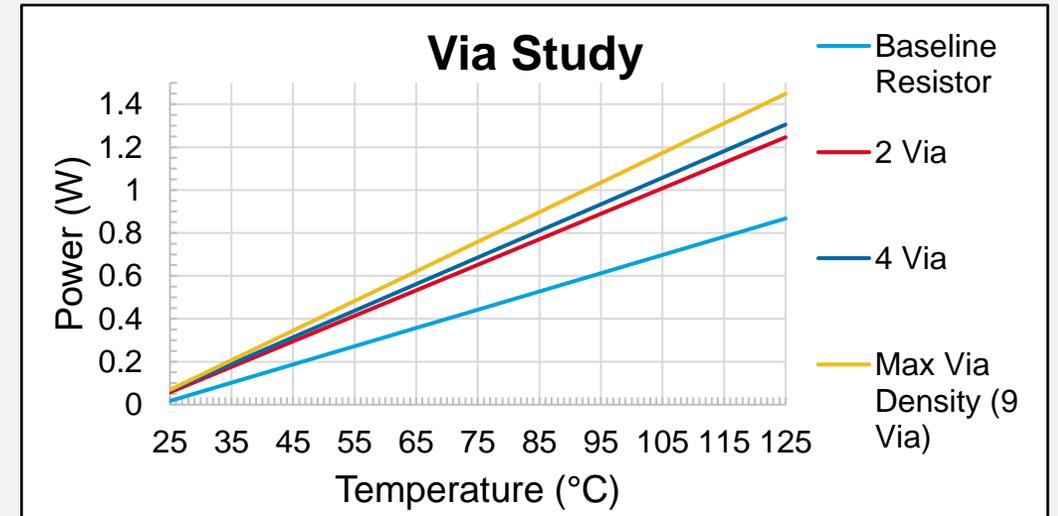
# Thermal Bridge

## Design Optimization – Via Density

- **Test conditions**
  - 2010 Resistor and 1111 Q Bridge
  - Via density varied from 2, 4, and 9
  - Measured over power until 125 °C was reached
- **Performance improved with max vias**
  - Adding Q Bridge with vias matters more than number of vias



Test boards with different vias illustrating the via placement when stepping from 2, 4, to 9 total vias



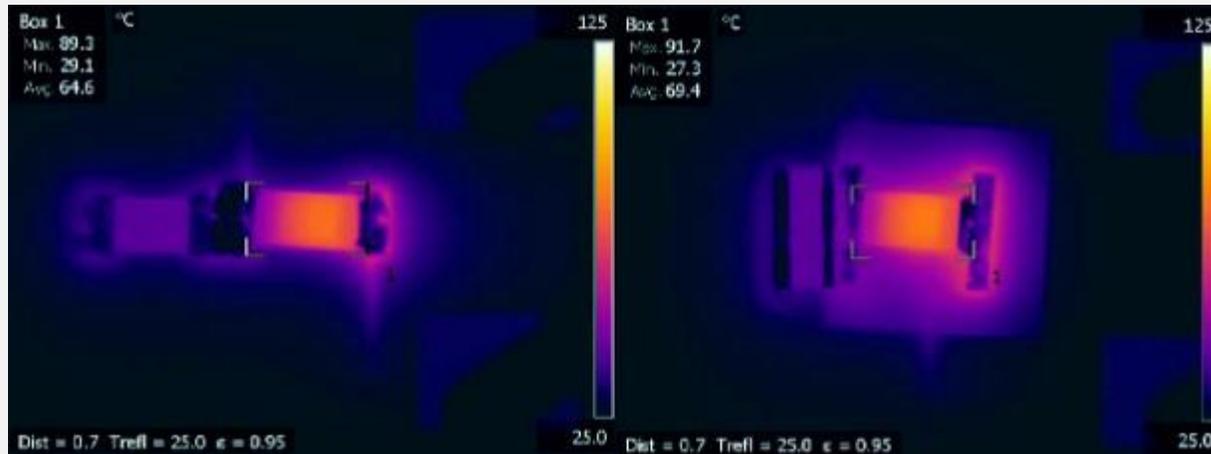
# Thermal Bridges

## Design Optimization – Heat Pipe Sizing

- **Test conditions**

- Number of vias fixed
- 2010 resistor
- Q Bridges varied

Q Bridge Size	Part Number	Cross Sectional Area (mm <sup>2</sup> )	Total Volume (mm <sup>3</sup> )	Termination Size (mm <sup>2</sup> )	Mounting Pad Size (mm <sup>2</sup> )
1020	QB1020A40ES [1]	5.2	13.2	2.6	5.4
1111	QB1111A40ES [1]	2.8	7.9	1.4	3
2010	QB2010A60WS [1]	3.7	18.1	1.9	4.5



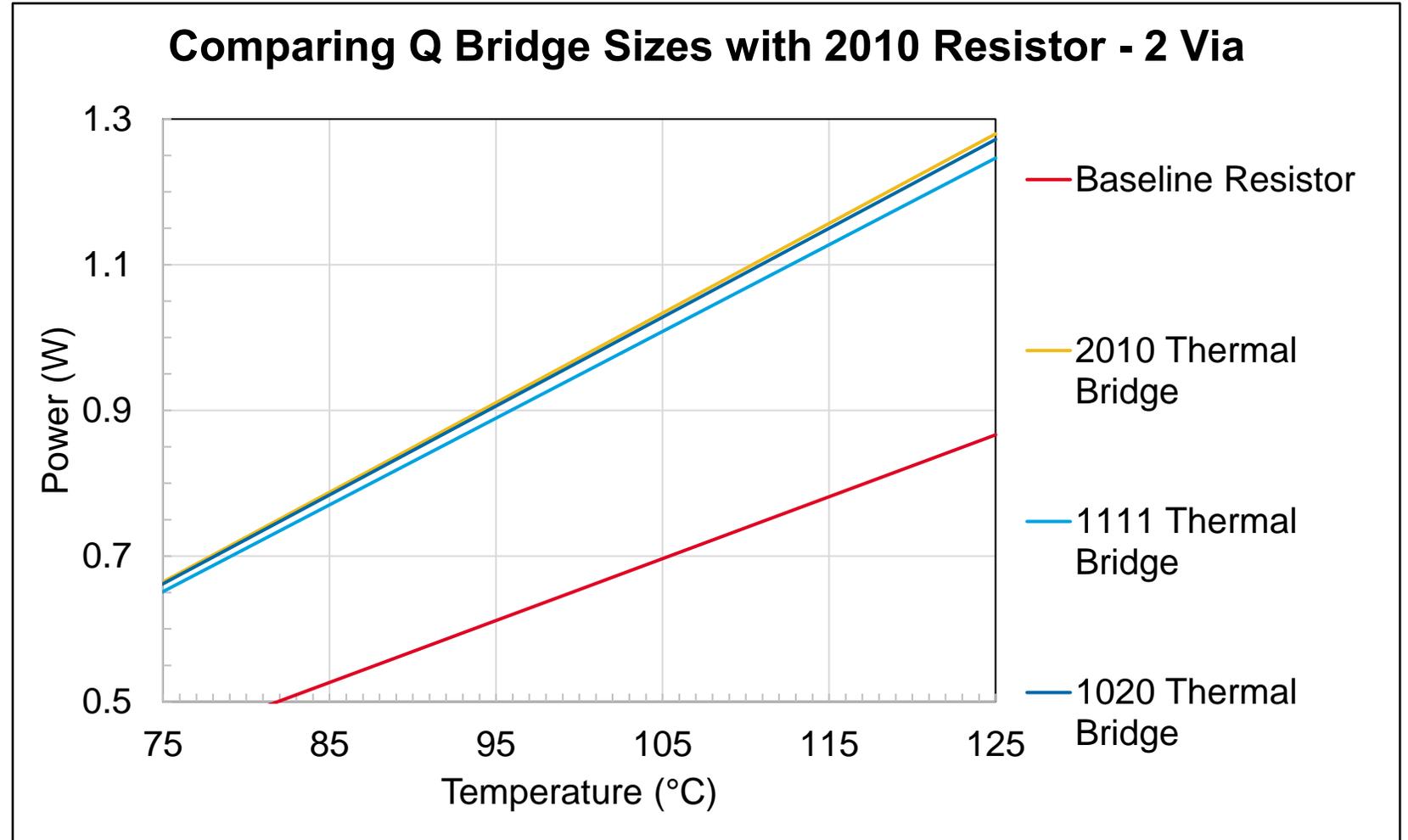
**Left** 2010 Resistor with 2010 sized thermal bridge; **Right** 2010 resistor with 1020 sized thermal bridge

# Thermal Bridges

## Design Optimization – Heat Pipe Sizing Results

### • Results

- The 1111 sized Q Bridge reduced the least amount of heat
- The 2010 and 1020 with similar volume and cross sectional area performed similarly



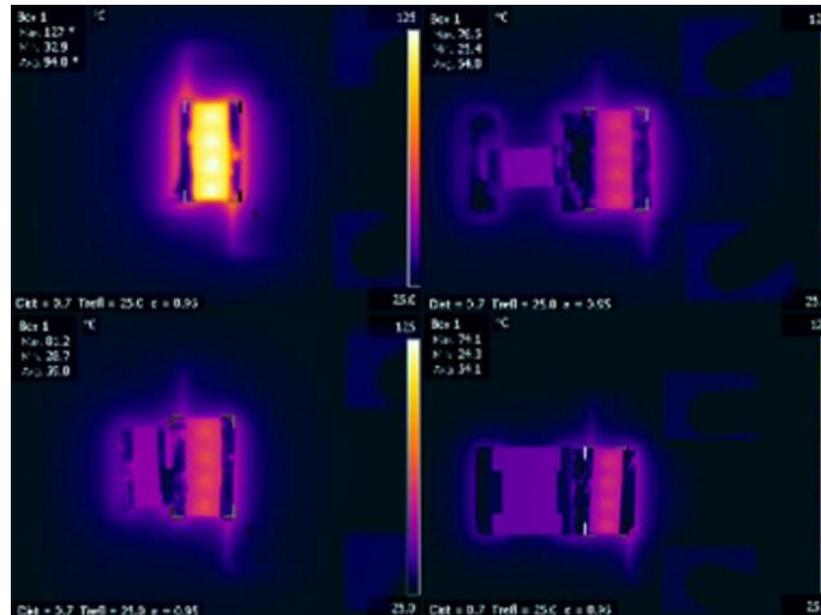
# Thermal Bridges

## Design Optimization – Heat Pipe Sizing Second Run

- **Test conditions**

- Number of vias fixed
- Resistor changed to 1020
  - Changes pad size
  - 2010 Q Bridge smaller width while larger area than 1020
- Q Bridges varied

Q Bridge Size	Part Number	Cross Sectional Area (mm <sup>2</sup> )	Total Volume (mm <sup>3</sup> )	Termination Size (mm <sup>2</sup> )	Mounting Pad Size (mm <sup>2</sup> )
1020	QB1020A40ES [1]	5.2	13.2	2.6	5.4
2525	QB2525A60WS [1]	9.7	58.9	6.7	12.8
2010	QB2010A60WS [1]	3.7	18.1	1.9	12.8



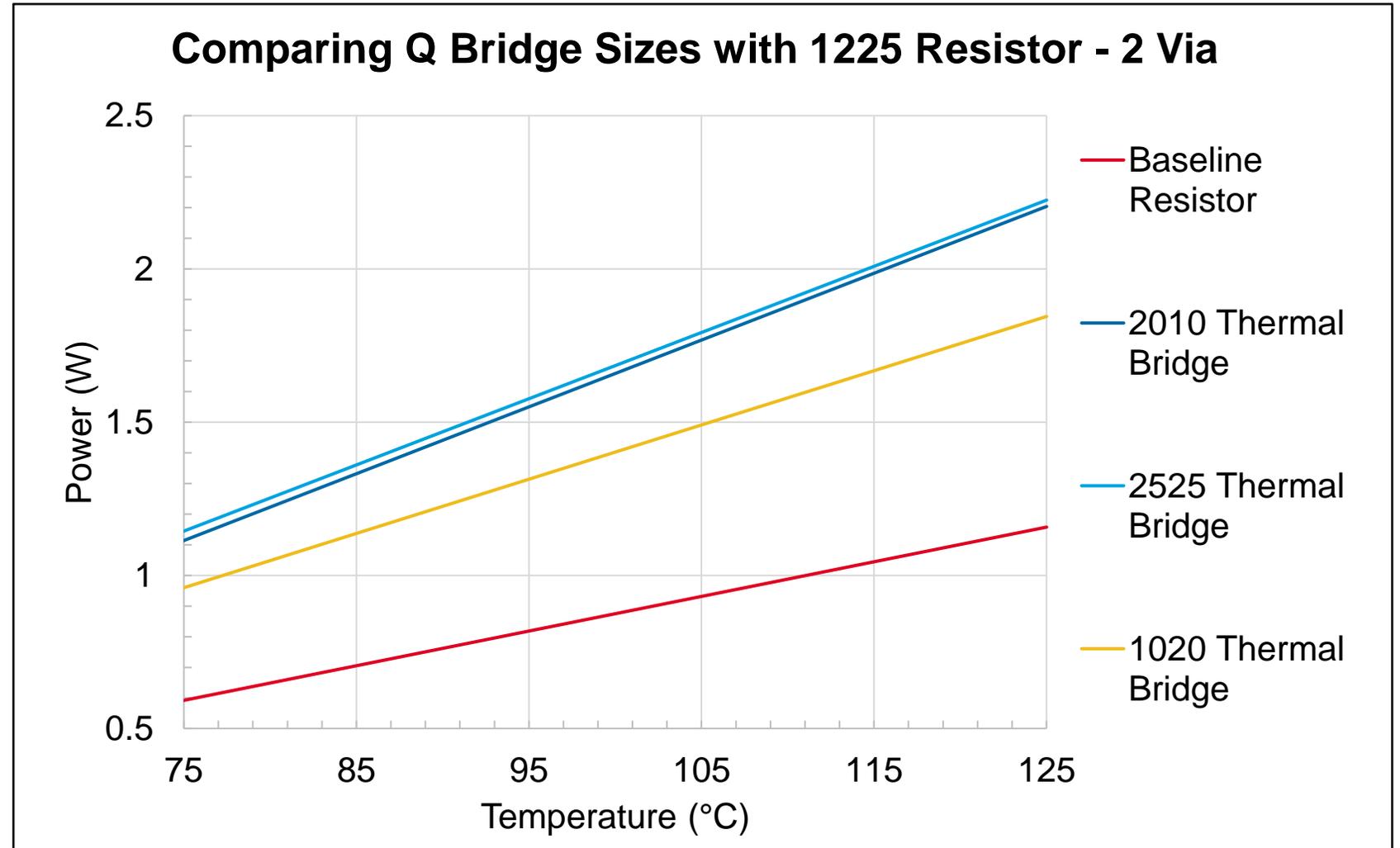
**Top Left** Baseline standalone 1225 sized resistor; **Bottom Left** 1225 Resistor with 1020 thermal bridge; **Top Right** 1225 Resistor with 2010 thermal bridge; **Bottom Right** 1225 Resistor with 2525 thermal bridge

# Thermal Bridges

## Design Optimization – Heat Pipe Sizing Second Run Results

### • Results

- The larger volume 2525 Q Bridge is able to remove more heat than the other sizes
- The 2010 performs better than the 1020
  - Larger volume
  - Larger pad sizes



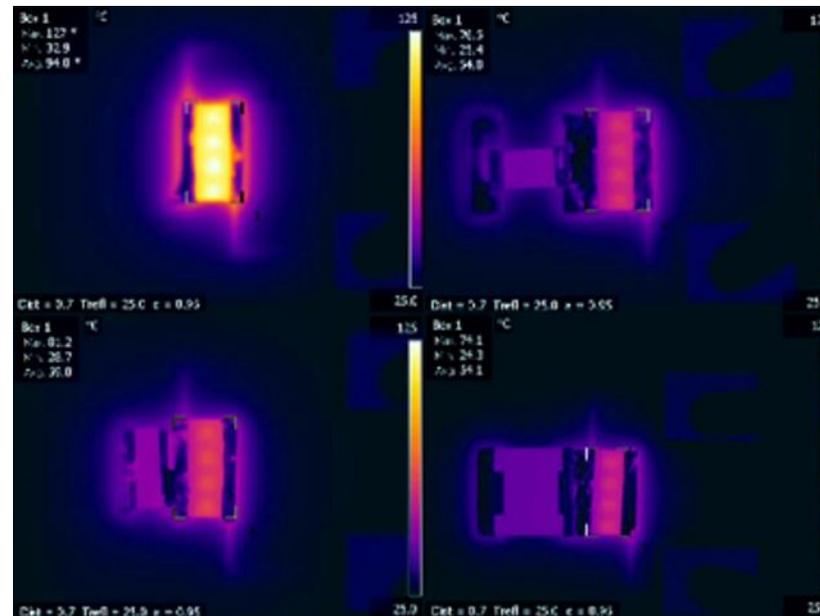
# Thermal Bridges

## Optimized Performance – Max Via Density

- **Test conditions**

- 1020 resistor used
- Number of vias maximized for pad size
- Q Bridges varied (match second run)

Q Bridge Size	Part Number	Cross Sectional Area (mm <sup>2</sup> )	Total Volume (mm <sup>3</sup> )	Termination Size (mm <sup>2</sup> )	Mounting Pad Size (mm <sup>2</sup> )
1020	QB1020A40ES [1]	5.2	13.2	2.6	5.4
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**Top Left** Baseline standalone 1225 sized resistor; **Bottom Left** 1225 Resistor with 1020 thermal bridge; **Top Right** 1225 Resistor with 2010 thermal bridge; **Bottom Right** 1225 Resistor with 2525 thermal bridge

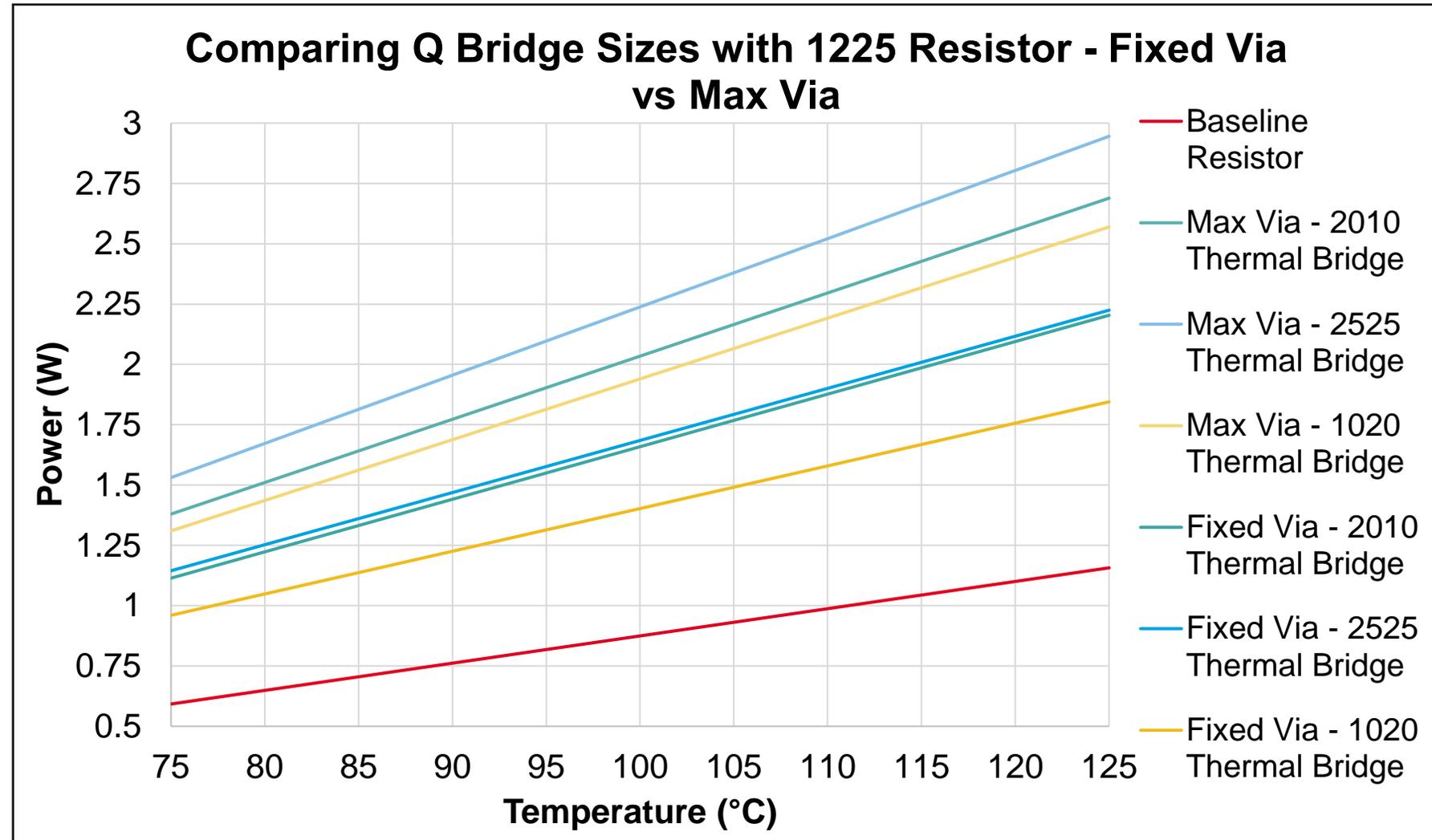
# Thermal Bridges

## Design Optimization – Heat Pipe Sizing Results

- **Results**

- With maximized vias the larger Q Bridges maximize performance results

- **Power handling of the part goes from 1.15W to 2.95W**



# Thermal Bridges

## Side by Side Videos

