Thermal Inspection of Low Emissivity Surfaces Using a Pulsed Light Emitting Diodes (PLED) Heat Source

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Outline

- Introduction/Motivation
- Pulsed Light Emitting Diodes (PLED) Heat Source Description and Setup
- PLED Thermography Inspection Results
  - Unpainted Aluminum Sample with Material Loss
  - Unpainted Aluminum Sample with Circular Material Loss
  - Polished Ti-6Al-4V Disk Inspection
- Quantitative Single Side Model Fit
- Conclusions

Introduction

Objectives

• Develop heat source for reflective (low emissivity) surfaces and therefore remove requirement to paint or apply a stick-on emissivity enhancement layer

• Investigate the use of high-powered LED chips for thermal nondestructive evaluation

• Measure sample with known defects and compare to conventional flash thermography

• Investigate quantitative thermal NDE with PLED heat source

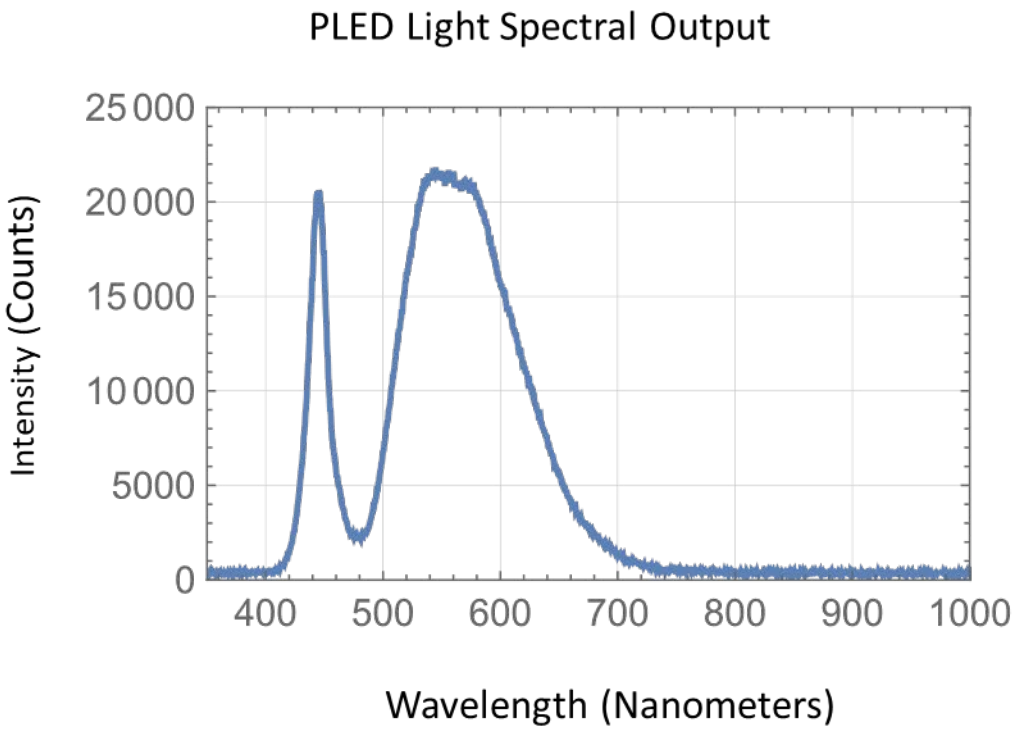
Payoffs

• Inspection of area “as is” saves inspection complexity, time and cost especially for large area inspections

• Improve model based quantitative single side thermal inspections

PLED Light Configuration and Spectral Output

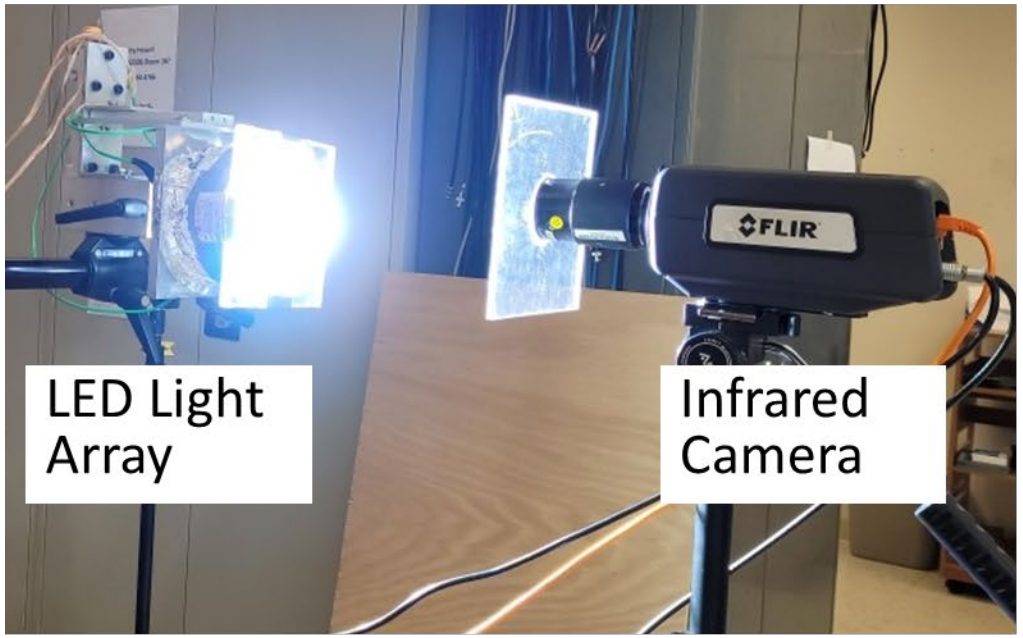
PLED Light Configuration



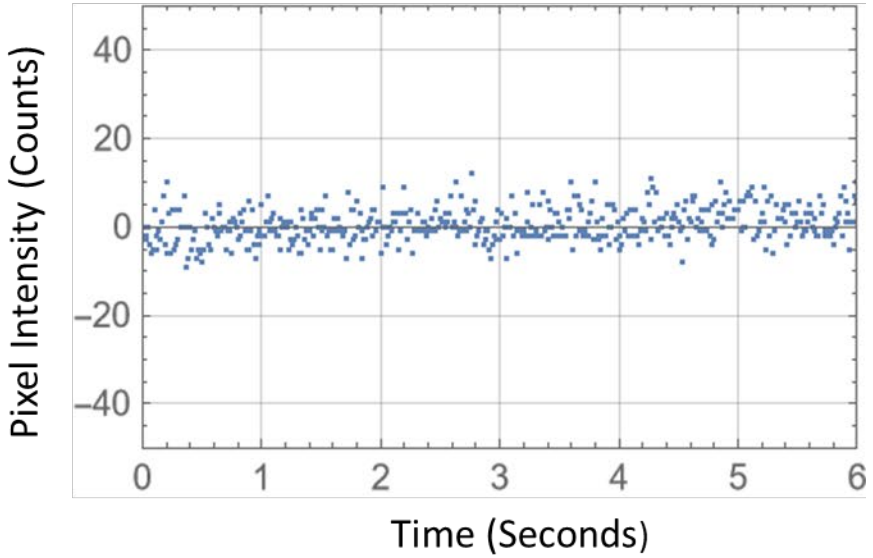
Direct View Observation of Heat Source

Nondestructive Evaluation Sciences Branch

Direct View of Heat Source

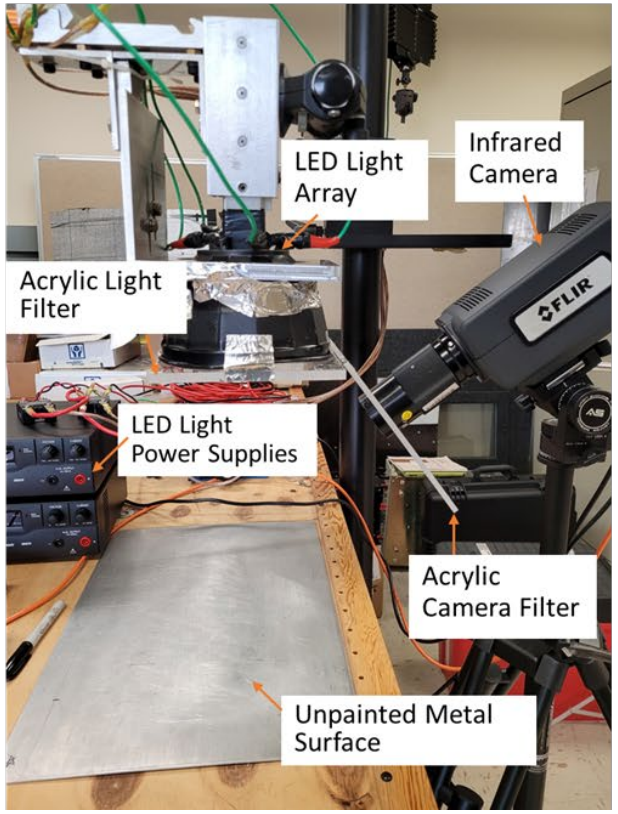


Single Pixel Plot

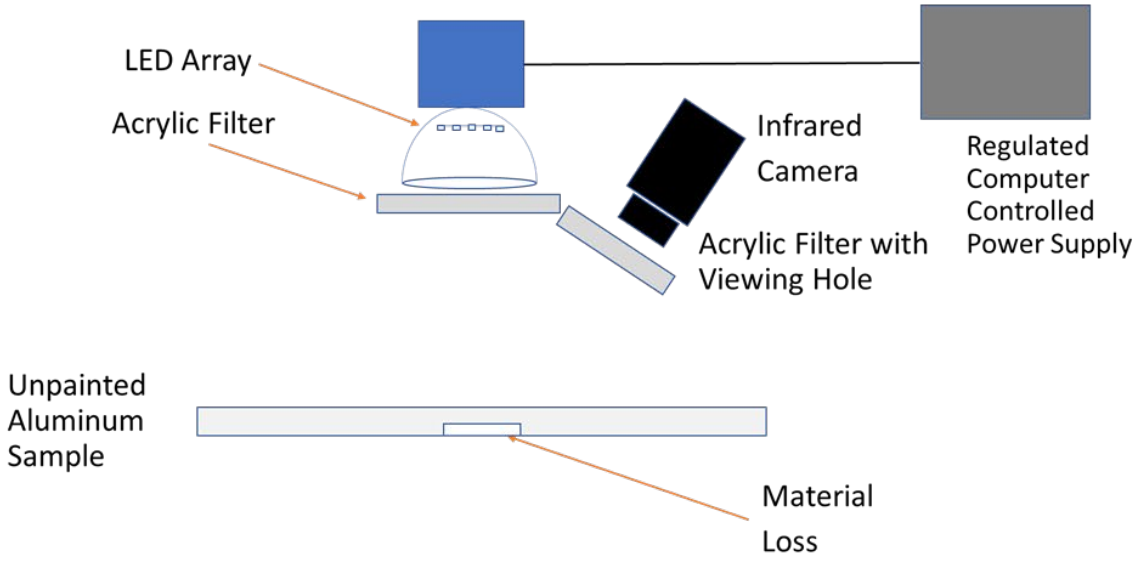


PLED Thermal Inspection Setup

PLED Thermal Inspection System



Drawing of PLED Thermal Inspection System



Emissivity Measurement of Inspected Samples

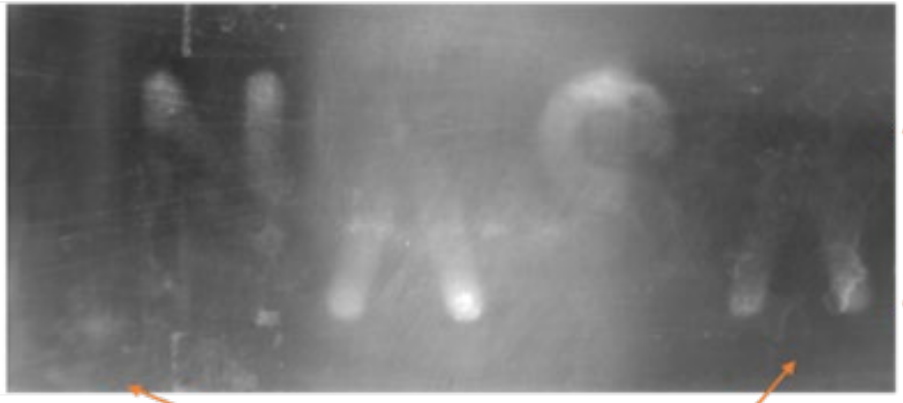
Sample	Average Surface Temperature (Celsius)	Measured Emissivity
Unpainted Aluminum Sample with Material Loss	39.3	0.35 +/- 0.020
Unpainted Aluminum Sample with Circular Material Loss	44.3	0.21 +/- 0.012
Polished Additive Manufactured Ti-6Al-4V Disk	65.8	0.39 +/- 0.017
Painted Aluminum Sample	34.3	0.90 +/- 0.008

Inspection of Aluminum Sample with Material Loss

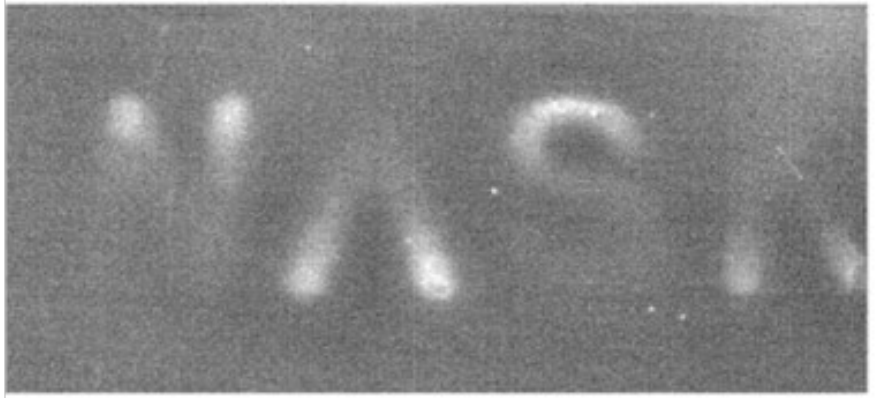
Picture Front

Picture Back

Flash Thermal Inspection



PLED Thermal Inspection

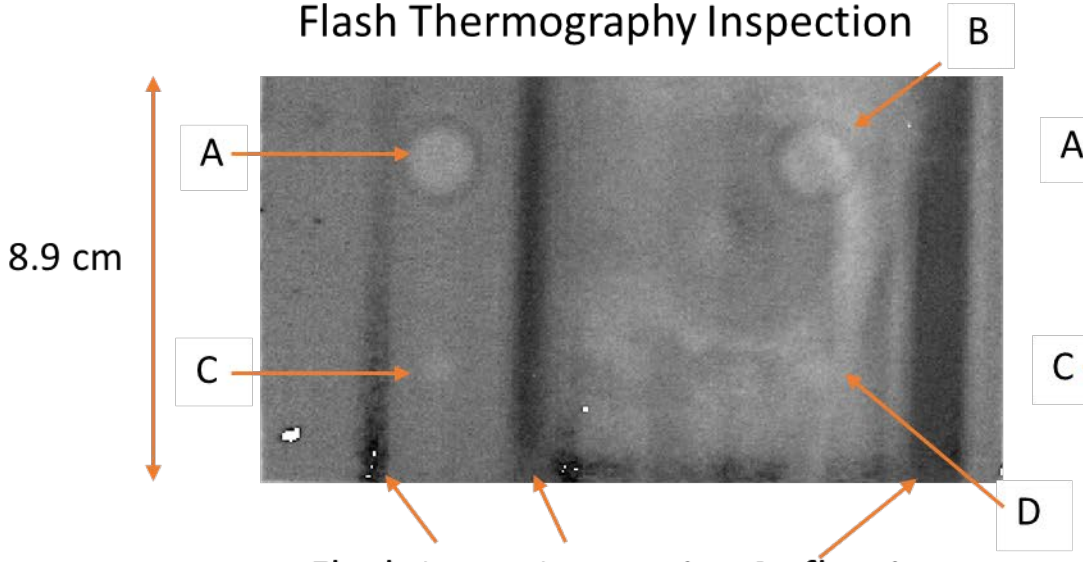


Inspection of Aluminum Sample with Circular Material Loss

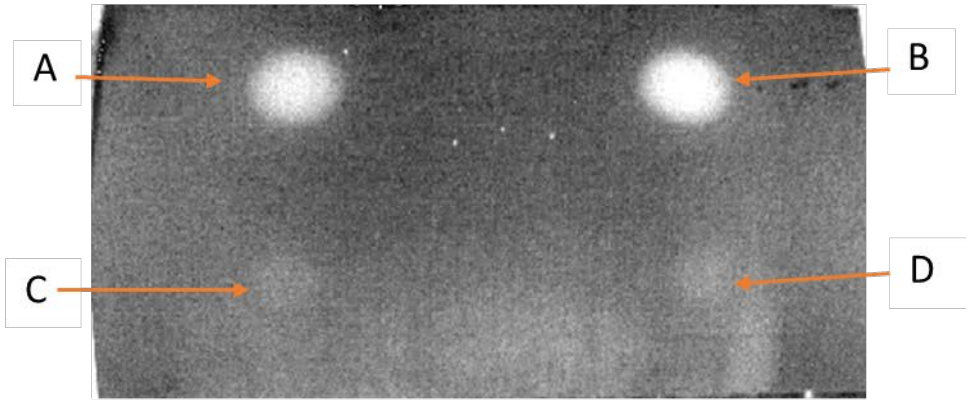
Picture Front

Picture Back

Flash Thermography Inspection



PLED Thermography Inspection

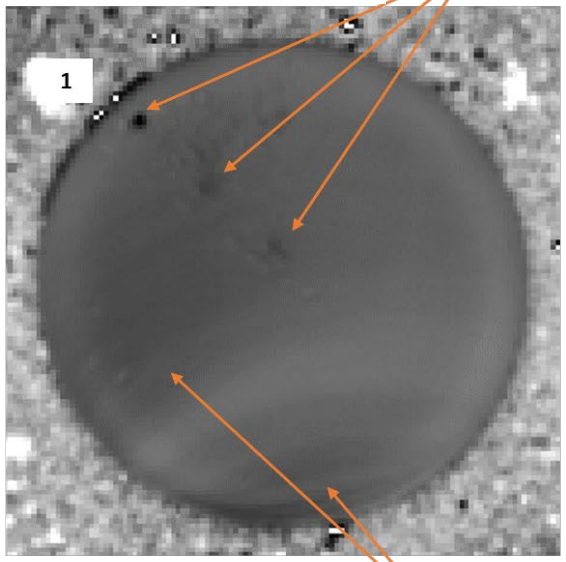


Inspection of Unpainted Polished Ti-6Al-4V Additively Manufactured Disk

Polished Disk

21.0 mm

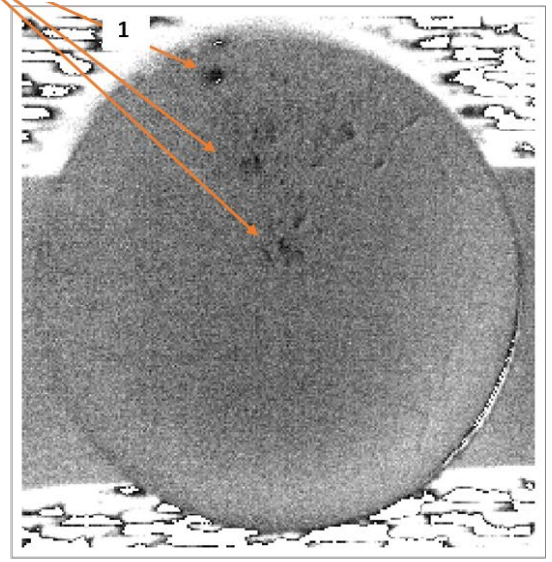
Flash Inspection



Porosity Indications

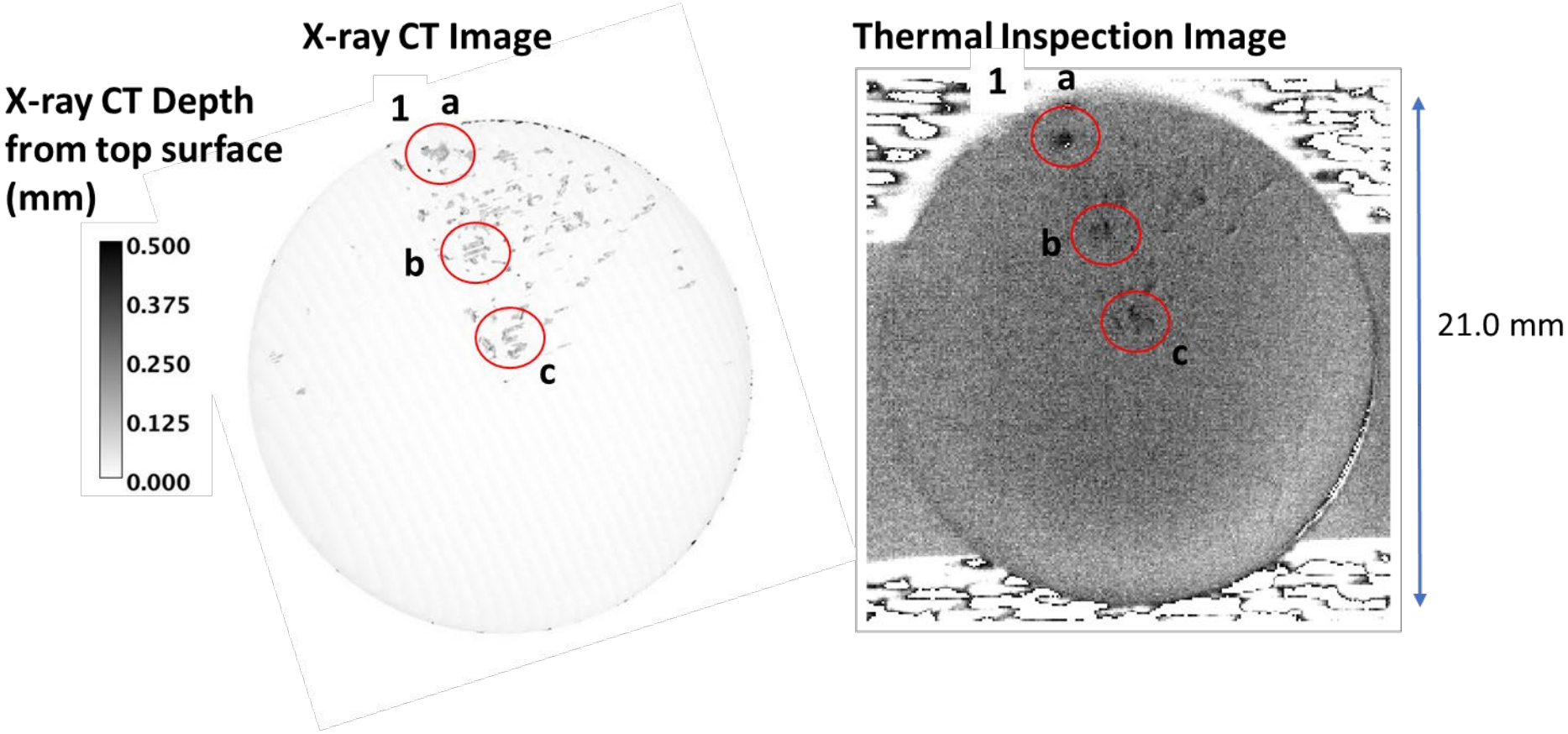
Flash Inspection Reflections

PLED Inspection



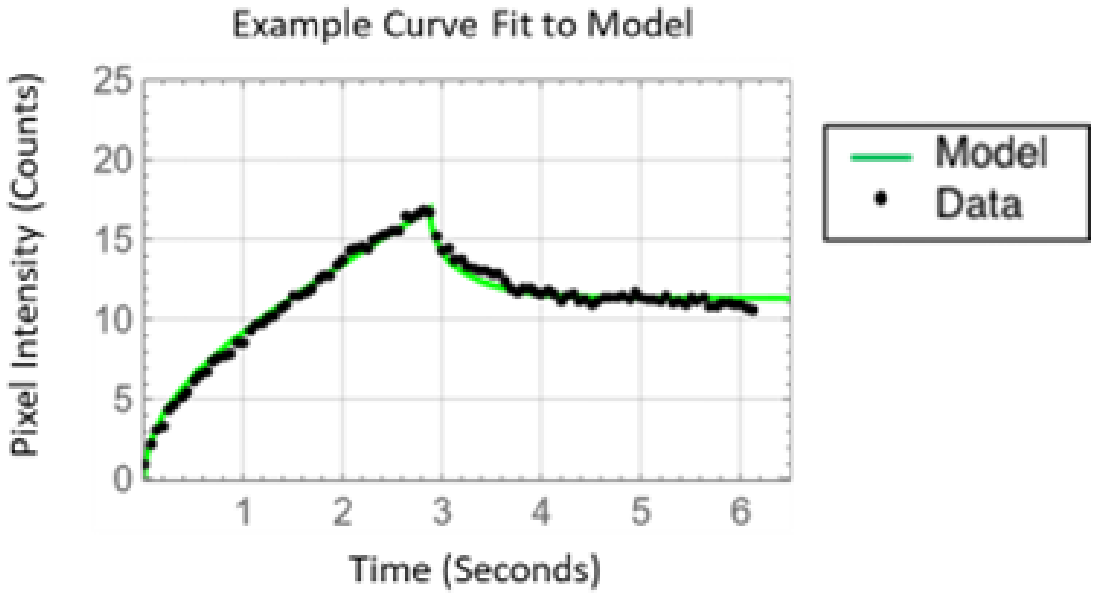
21.0 mm

PLED Thermography Comparison to X-ray CT of Ti-6Al-4V Disk



PLED Single Side Inspection of Ti-6Al-4V Disk with Model Fit

$$T(t,l) = \frac{(F_0\ t\ \alpha)}{K\ l} + \frac{F_0\ l}{K}\left(\frac{1}{3} - \frac{2}{\pi^2}\left(\sum_{n=1}^{nmax}\frac{-1^{2n}}{n^2}\ e^{\frac{-\alpha\ n^2\pi^2\ t}{l^2}}\right)\right) - \frac{(F_0\ (t-t_0\ )\ \alpha)}{K\ l} - \frac{F_0\ l}{K}\left(\frac{1}{3} - \frac{2}{\pi^2}\left(\sum_{n=1}^{nmax}\frac{-1^{2n}}{n^2}\ e^{\frac{-\alpha\ n^2\pi^2(t-t_0\ )}{l^2}}\right)\right)U(t-t_0)$$



- Quantitative Single Side Model-Based Thermal NDE is Possible with the PLED Heat Source, α = 0.022 cm2/sec, literature thermal diffusivity value for solid Ti-6AL-4V is 0.029 cm2/sec

Conclusions

- The PLED heat source has been demonstrated as a viable heat source for thermal inspection of low emissivity surfaces
- The PLED heat source advantage is the light is not observable with the mid-wave infrared camera
- Single sided model fit revealed good agreement to the data and therefore quantitative single side model-based thermal NDE is possible with the PLED heat source

Acknowledgements

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