Claims

1. A method for localizing hot spots in a multi layered device under test (DUT) by using lock-in thermography (LIT) where plural hot spots of electrical circuits are buried in the DUT at different depth layers from a bottom layer to a top layer, comprising:

applying test signals of multiple frequencies to the electrical circuits of the DUT for exciting the hot spots;

imaging a top surface of the top layer of the DUT at timed intervals to obtain IR images of the DUT while the test signal is applied to the electrical circuits, wherein the images are in correlation to a propagation of heat from the hot spots in the DUT;

detecting the thermal response signals at the timed intervals from the images taken from the DUT; and

determining changes in the appearance of hot spot images on the top surface of the DUT in relation to the frequencies of the test signals.

2. The method of claim 1, wherein determining changes in the appearance of hot spot images comprises determining the timing of the disappearance of hot spot images on the surface of the DUT in relation to the frequencies of the test signals.

3. The method of claim 1, wherein determining changes in the appearance of hot spot images comprises determining a change of an oval shaped hot spot image generated by at least two laterally closely neighboring hot spots at a certain depth curve into two separate hot spot images in relation to the frequencies of the test signals.

4. The method of claim 1, wherein determining changes in the appearance of hot spot images comprises determining a change of an oval shaped hot spot image generated by at least two laterally closely neighboring hot spots at different depth levels into a separate hot spot image generated by one of the two hot spot in relation to the frequencies of the thermal response signals.

5. The method of claim 1, wherein, imaging the top surface of the DUT at timed intervals comprises averaging an image of the top surface of the DUT which was generated at an end of a previous timed interval with an image of the of the top surface of the DUT taken at an end of a subsequent timed interval.

6. The method of claim 2, wherein a signal-to-noise ratio of the detected thermal response signal is determined and the presence of a hot spot is detected where the signal-to-noise ratio of the thermal response signals is above a predetermined reference value.

7. The method of claim 1, wherein the method further comprises displaying on a monitor the image(s) of the hot spot(s) or the timing of the disappearance of hot spot images on the top surface of the DUT in relation to the frequencies of the test signals.

8. A system for localizing hot spots in a multi layered device under test (DUT) by using lock-in thermography (LIT) where plural hot spots of electrical circuits are buried in the DUT at different depth layers from a bottom to a top layer, comprising:

A sync signal input for receiving a sync signal corresponding to test signals of multiple frequencies applied to the electrical circuits of the DUT for exciting the plural hot spots;

an infrared camera for imaging a top surface of the top layer of the DUT at timed intervals corresponding to the sync signal to obtain IR images of the DUT while the test signal of one of the multiple frequencies is applied to the electrical circuits wherein the images are in correlation to a propagation of heat from the hot spots in the DUT;

and a processor configured to:

receive data from the infrared camera and to use the IR images of the infrared camera for detecting thermal response signals at the timed intervals; and

determine changes in the appearance of hot spot images on the top surface of the DUT in relation to the frequencies of the thermal response signals.

9. The system of claim 8, wherein the processor is configured to determine changes in the appearance of hot spot images by determining the timing of the disappearance of hot spot images on the surface of the DUT in relation to the frequencies of the thermal response signals.

10. The system of claim 8, wherein the processor is configured to determine changes in the appearance of hot spot images by determining a change of an oval shaped hot spot image generated by at least two laterally closely located hot spots to two separate hot spot images in relation to the frequencies of the thermal response signals.

11. The system of claim 8, wherein the processor is configured to determine changes in the appearance of hot spot images by determining a change of an oval shaped hot

spot image generated by at least two laterally closely located hot spots to a separate hot spot image generated by one hot spot in relation to the frequencies of the thermal response signals.

12. The method of claim 8, wherein, while the imaging the top surface of the DUT at timed intervals, an image of the top surface of the DUT which image was taken at an end of a previous timed interval, is replaced by an image of the of the top surface of the DUT taken at an end of a subsequent timed interval.

13. The method of claim 9, wherein a signal-noise ratio of the detected thermal response signals, and detecting the presence of a hot spot where a signal-to-noise ratio of the thermal response signals is above a predetermined reference value.

14. The system of claim 8, further comprising a monitor for displaying the image(s) of the hot spot(s) or the timing of the disappearance of hot spot images on the to surface of the DUT in relation to the frequencies of the thermal response signals.

15. A method for localizing and resolving a plurality of hot spots in an electrical device, comprising:

applying to the electrical device a plurality of test signals, each test signal consisting of a train of pulses at a selected frequency, wherein each of the plurality of test signals has different selected frequency;

during application of each of the plurality of test signals capturing a plurality of infrared (IR) images;

for each of the plurality of test signals selecting at least one plurality of infrared (IR) images as representative image to thereby generate a series of representative images arranged in a progression of increasing selected frequency; and,

analyzing changes in appearance of each hot spot in the series of representative images along the progression of increasing selected frequency to thereby localize and resolve hot spots within the electrical device.

Claims

1. A method for localizing hot spots in a multi layered device under test (DUT) by using lock-in thermography (LIT) where plural hot spots of electrical circuits are buried in the DUT at different depth layers from a bottom layer to a top layer, comprising:
applying test signals of multiple frequencies to the electrical circuits of the DUT for exciting the hot spots;
imaging a top surface of the top layer of the DUT at timed intervals to obtain IR images of the DUT while the test signal is applied to the electrical circuits, wherein the images are in correlation to a propagation of heat from the hot spots in the DUT;
detecting the thermal response signals at the timed intervals from the images taken from the DUT; and
determining changes in the appearance of hot spot images on the top surface of the DUT by determining the timing of the disappearance of hot spot images on the surface of the DUT in relation to the frequencies of the test signals.

2. The method of claim 1, wherein determining changes in the appearance of hot spot images comprises determining a change of an oval shaped hot spot image generated by at least two laterally closely neighboring hot spots at a certain depth curve into two separate hot spot images in relation to the frequencies of the test signals.

3. The method of claim 1, wherein determining changes in the appearance of hot spot images comprises determining a change of an oval shaped hot spot image generated by at least two laterally closely neighboring hot spots at different depth levels into a separate hot spot image generated by one of the two hot spot in relation to the frequencies of the thermal response signals.

4. The method of claim 1, wherein, imaging the top surface of the DUT at timed intervals comprises averaging an image of the top surface of the DUT which was generated at an end of a previous timed interval with an image of the top surface of the DUT taken at an end of a subsequent timed interval.

5. The method of claim 1, wherein, while imaging the top surface of the DUT at timed intervals, an image of the top surface of the DUT which image was taken at an end of a previous timed interval, is replaced by an image of the top surface of the DUT taken at an end of a subsequent timed interval.

6. The method of claim 1, wherein a signal-to-noise ratio of the detected thermal response signal is determined and the presence of a hot spot is detected where the signal-to-noise ratio of the thermal response signals is above a predetermined reference value.

7. The method of claim 1, wherein the method further comprises displaying on a monitor the image(s) of the hot spot(s) or the timing of the disappearance of hot spot images on the top surface of the DUT in relation to the frequencies of the test signals.

8. The method of claim 1 for localizing and resolving a plurality of hot spots in an electrical device, comprising:
applying to the electrical device a plurality of test signals, each test signal consisting of a train of pulses at a selected frequency, wherein each of the plurality of test signals has different selected frequency;
during application of each of the plurality of test signals capturing a plurality of infrared (IR) images;
for each of the plurality of test signals selecting at least one plurality of infrared (IR) images as representative image to thereby generate a series of representative images arranged in a progression of increasing selected frequency; and,
analyzing changes in appearance of each hot spot in the series of representative images along the progression of increasing selected frequency to thereby localize and resolve hot spots within the electrical device.

9. A system for localizing hot spots in a multi layered device under test (DUT) by using lock-in thermography (LIT) where plural hot spots of electrical circuits are buried in the DUT at different depth layers from a bottom to a top layer, comprising:
a sync signal input for receiving a sync signal corresponding to test signals of multiple frequencies applied to the electrical circuits of the DUT for exciting the plural hot spots;
an infrared camera for imaging a top surface of the top layer of the DUT at timed intervals

corresponding to the sync signal to obtain IR images of the DUT while the test signal of one of the multiple frequencies is applied to the electrical circuits wherein the images are in correlation to a propagation of heat from the hot spots in the DUT; and

a processor configured to:

receive data from the infrared camera and to use the IR images of the infrared camera for detecting thermal response signals at the timed intervals; and

determine changes in the appearance of hot spot images on the top surface of the DUT by determining the timing of the disappearance of hot spot images on the surface of the DUT in relation to the frequencies of the thermal response signals.

10. The system of claim 9, wherein the processor is configured to determine changes in the appearance of hot spot images by determining a change of an oval shaped hot spot image generated by at least two laterally closely located hot spots to two separate hot spot images in relation to the frequencies of the thermal response signals.

11. The system of claim 9, wherein the processor is configured to determine changes in the appearance of hot spot images by determining a change of an oval shaped hot spot image generated by at least two laterally closely located hot spots to a separate hot spot image generated by one hot spot in relation to the frequencies of the thermal response signals.

12. The system of claim 9, wherein the processor is configured to determine a signal-noise ratio of the detected thermal response signals, and to detect the presence of a hot spot where a signal-to-noise ratio of the thermal response signals is above a predetermined reference value.

13. The system of claim 9, further comprising a monitor for displaying the image(s) of the hot spot(s) or the timing of the disappearance of hot spot images on the top surface of the DUT in relation to the frequencies of the thermal response signals.