Claims

1. Method for a non-destructive, non-contacting and image forming examination of a sample by means of the heat flow thermography method where the examination consists of evaluating an existence and/or depth distance values of any heat flow velocity transitions below a surface of the sample,
wherein the sample is excited by heat pulses of at least one excitation source, and a thermal flow originating therefrom is captured by at least one infrared sensor in an image sequence of thermal images, and wherein
the thermal images obtained from the image sequence are evaluated by means of a signal and image processing and depicting a thermal flow with a resolution in time and in space,
the method comprising:
exciting the sample at least twice independently from each other by means of the heat pulses from the excitation source where a second excitation and any succeeding excitation is delayed with respect to a preceding excitation by a time delay whereby the start of the captured sequence happens at another defined point of time within the time between two images within an image sequence;
detecting the respective total thermal flow processes generated by the at least two excitation processes of the sample by the infrared sensor in the independent image sequences containing the excitation as well as the thermal answer signal from the sample,
combining all captured image sequences to a total image sequence in which all images are arranged in a sequence which is correct in time with respect to the point of time of the pulse like excitation, and
extracting from the total image sequence, in a manner known per se, an indication of the depth distance of a heat flow velocity transition from a surface of the sample.

2. Method according to claim 1, wherein the indication of the depth distance of a heat flow velocity transition from a surface of the sample comprises the run time parameters related to the surface areas of the sample in a pixel related manner.

3. Method according to claim 1, wherein the total image sequence is corrected such that the pixel related intensity curves comprise a strictly monotones behavior in the areas to be evaluated.

4. Method according to claim 1, wherein any image sequence extends up the point of time when an equilibrium condition is reached with respect to the dissipation of the heat applied during the excitation of the sample.

5. Method according to claim 1, wherein a periodic excitation of the layered material is used wherein the starting point of the imaging of the respective independent image sequence is displaced with respect to the starting point of the periodic excitation to another defined point in time.

6. Method according to any of the claims 1 to 5, wherein the delay of the independent image sequences is carried out in equal time portions.

7. Method according to claims 1 to 6, wherein the length of the equal portions in time of the delay of the independent image sequences is defined as the quotient of the time between two images within an image sequence divided by the number of the independently captured image sequences n.

8. Method according to claims 1 to 7, wherein the image intensity of each captured image sequence is corrected so that all captured image sequences have the same intensity offset.

9. Method according to claims 1 to 8, wherein one of the captured image sequence is used as a reference sequence for correcting the image intensity in the rest of the captured image sequences.

10. Method according to claims 1 to 9, wherein the first captured image sequence serves as a reference sequence for correcting the image intensity in the rest of the captured image sequences.

11. Method according to claim 1 or 2, wherein the sample comprises a structure of a layered material comprising a base layer and at least one layer additional layer, wherein
the run time parameter is extracted related to pixels from the respective thermal flow procedures of the total image sequence, and
from the run time parameter respective depth distance values of a heat flow velocity transition from a surface of the layered structure are calculated which are put together to an image covering the surface area of the layered structure of the sample.

12. Method according to claim 11, wherein the reconstruction of at least one layer of the total layer structure of a layered material is carried out based on the physical model thereof wherein the run time parameters of the respective pixel related heat flow processes of the total image sequence are extracted by correlating the respective thermal answer signals of the layered material with the previously calculated pulse answer signals for different run times of appropriate lengths, and wherein
all layer thickness values are calculated from the detected run time parameters in knowledge of diffusivity values of corresponding layers of the layered structure.

13. Method according to claim 1wherein the sample comprises a substrate or a work piece including defects close to a surface of the substrate which defects are heat flow velocity transitions experienced by the heat flow from the surface of the sample into a body of the sample, wherein
the indication of presence and depth distance of a particular defect is a hot spot in a respective image of the image sequence which respective image was taken at a time distance from the excitation of the sample related to the depth distance of the defect from the surface of the sample.

Claims

1. Method for a non-destructive, non-contacting and image forming examination of a sample by means of the heat flow thermography method where the examination consists of evaluating an existence and/or depth distance values of any heat flow velocity transitions below a surface of the sample,
wherein the sample is excited by heat pulses of at least one excitation source, and a thermal flow originating therefrom is captured by at least one infrared sensor in an image sequence of
thermal images, and wherein
the thermal images obtained from the image sequence are evaluated by means of a signal and image processing and depicting a thermal flow with a resolution in time and in space, the method comprising:
exciting the sample at least twice independently from each other by means of the heat pulses from the excitation source where a second excitation and any succeeding excitation is delayed with respect to a preceding excitation by a time delay whereby the start of the captured sequence happens at another defined point of time within the time between two images within an image sequence;
detecting the respective total thermal flow processes generated by the at least two excitation processes of the sample by the infrared sensor in the independent image sequences containing the excitation as well as the thermal answer signal from the sample,
combining all captured image sequences to a total image sequence in which all images are arranged in a sequence which is correct in time with respect to the point of time of the pulse like excitation, and
extracting from the total image sequence an indication of the depth distance of a heat flow velocity transition from a surface of the sample,
wherein the run time parameter is extracted related to pixels from the thermal flow procedures of the total image sequence, and

from the run time parameter depth distance value of a heat flow velocity transition from a surface of the sample is calculated which is put together to an image covering the surface area of the sample.

2. Method according to claim 1, wherein the indication of the depth distance of a heat flow velocity transition from a surface of the sample comprises the run time parameters related to the surface areas of the sample in a pixel related manner.

3. Method according to claim 1, wherein the total image sequence is corrected such that the pixel related intensity curves comprise a strictly monotones behavior in the areas to be evaluated.

4. Method according to claim 1, wherein any image sequence extends up the point of time when an equilibrium condition is reached with respect to the dissipation of the heat applied during the excitation of the sample.

5. Method according to claim 1, wherein a periodic excitation of the layered material is used wherein the starting point of the imaging of the respective independent image sequence is displaced with respect to the starting point of the periodic excitation to another defined point in time.

6. Method according to claim 1, wherein the delay of the independent image sequences is carried out in equal time portions.

7. Method according to claim 1, wherein the length of the equal portions in time of the delay of the independent image sequences is defined as the quotient of the time between two images within an image sequence divided by the number of the independently captured image sequences n.

8. Method according to claim 1, wherein the image intensity of each captured image sequence is corrected so that all captured image sequences have the same intensity offset.

9. Method according to claim 1, wherein one of the captured image sequence is used as a reference sequence for correcting the image intensity in the rest of the captured image sequences.

10. Method according to claim 1, wherein the first captured image sequence serves as a reference sequence for correcting the image intensity in the rest of the captured image sequences.

11. Method according to claim 1, wherein the sample comprises a structure of a layered material comprising a base layer and at least one additional layer, wherein the run time parameter for the base layer and the run time parameter for the additional layer are extracted related to pixels from the respective thermal flow procedures of the total image sequence, and from the run time parameters respective depth distance values of a heat flow velocity transition from a surface of the layered structure are calculated which are put together to an image covering the surface area of the layered structure of the sample.

12. Method according to claim 11, wherein the reconstruction of at least one layer of the total layer structure of a layered material is carried out based on the physical model thereof wherein the run time parameters of the respective pixel related heat flow processes of the total image sequence are extracted by correlating the respective thermal answer signals of the layered material with the previously calculated pulse answer signals for different run times of appropriate lengths, and wherein all layer thickness values are calculated from the detected run time parameters in knowledge of diffusivity values of corresponding layers of the layered structure.

13. Method according to claim 1, wherein the sample comprises a substrate or a work piece including defects close to a surface of the substrate which defects are heat flow velocity transitions experienced by the heat flow from the surface of the sample into a body of the sample, wherein the indication of presence and depth distance of a particular defect is a hot spot in a respective image of the image sequence which respective image was taken at a time distance from the excitation of the sample related to the depth distance of the defect from the surface of the sample.

14. Method according to claim 1, wherein the run time parameter is extracted out of area of intensity curve of total image sequence.

15. Method according to claim 11, wherein the run time parameter of the base layer and the the run time parameter of the additional layer are extracted out of respective areas of the intensity curves of total image sequence.