

Claims

1. Measurement system (1) for characterizing sample tissue (4; 4a, 4b) in a non-invasive way, comprising:

5 at least one stimulation device (3; 3a, 3b; 3a, 3c) for thermal stimulation of the sample tissue (4; 4a, 4b),
 at least one temperature sensor (2; 2a, 2b) for capturing at least one temperature profile of the sample tissue (4),

10 a computing unit (11) connected to the temperature sensor (2; 2a, 2b) for processing data delivered by the temperature sensor (2; 2a, 2b),

 wherein thermal radiation radiated by the sample tissue (4; 4a, 4b) from at least a measurement area (5) as
15 a result of the thermal stimulation is detectable by the at least one temperature sensor (2; 2a, 2b) during the thermal stimulation of the sample tissue (4; 4a, 4b),

 wherein the at least one stimulation device comprises at least one temperature regulating body (3; 3a, 3b; 3a,
20 3c) which is in continuous contact with the sample tissue (4; 4a, 4b) in a contact area (6) during an entire measurement period, wherein during a measurement period the at least one temperature regulating body (3; 3a, 3b; 3a, 3c) has a different temperature than the sample tissue (4;
25 4a, 4b).

2. Measurement system according to claim 1, wherein the at least one temperature sensor (2; 2a, 2b) is a contactless temperature sensor, particularly a thermopile
30 sensor or a thermographic camera, particularly wherein two temperature sensors are provided for measuring temperatures of adjacent volumes or areas or of different points of the sample tissue (4; 4a, 4b).

3. Measurement system according to one of the preceding claims, wherein a lens (14) and/or a filter attributed to each temperature sensor (2; 2a, 2b) is arranged between said at least one temperature sensor (2; 2a, 2b) and said at least one measurement area (5).

4. Measurement system according to one of the preceding claims, wherein an auxiliary temperature sensor (12) is provided for monitoring a temperature of the temperature regulating body (3; 3a, 3b; 3a, 3c).

5. Measurement system according to one of the preceding claims, wherein the temperature regulating body (3; 3a, 3b; 3a, 3c) and the at least one temperature sensor (2; 2a, 2b) are arranged in such a way that the contact area (6) and the measurement area (5) are adjacent, particularly wherein the contact area (6) doesn't surround the measurement area (5) or vice versa.

6. Measurement system according to one of the claims 1 to 4, wherein, in case one temperature regulating body (3) is used, the temperature regulating body (3) and the at least one temperature sensor (2; 2a, 2b) are arranged in such a way that the contact area (6) and the measurement area (5) are adjacent, particularly wherein the contact area (6) surrounds the measurement area (5) at least partially.

7. Measurement system according to one of the claims 1 to 5, wherein two temperature regulating bodies (3a, 3b; 3a, 3c) are provided, which contact the sample tissue (4; 4a, 4b) such that the measurement area (5) of the at least one temperature sensor (2; 2a, 2b) is located between the two temperature regulating bodies (3a, 3b; 3a, 3c).

8. Measurement system according to one of the preceding claims, wherein the temperature regulating body (3) or at least one of the temperature regulating bodies (3a, 3b; 3a, 3c) comprises or comprise, respectively, a layer or a coating (8) adapted for increasing heat transfer between the sample tissue (4; 4a, 4b) and the temperature regulating body (3) or the at least one of the temperature regulating bodies (3a, 3b; 3a, 3c), particularly wherein the layer or the coating (8) is made of heat conductive silicon, particularly wherein a thickness of the layer or coating (8) is between 100 and 10000 μm .

9. Measurement system according to one of the preceding claims, wherein the temperature regulating body (3; 3a, 3b; 3a, 3c) is a cooling body adapted to be cooled by a cold reservoir body (9) having a higher heat capacity than the cooling body (3; 3a, 3b; 3a, 3c) and which is in contact with the cooling body (3; 3a, 3b; 3a, 3c) or integrated in the cooling body (3; 3a, 3b; 3a, 3c) or wherein the temperature regulating body (3; 3a, 3b; 3a, 3c) is a cooling body adapted to be actively cooled by a cooling device.

10. Measurement system according to one of the claims 1 to 7, wherein the temperature regulating body (3; 3a, 3b; 3a, 3c) is a heating body adapted to be heated by a heat reservoir body (9) having a higher heat capacity than the heating body (3; 3a, 3b; 3a, 3c) and which is in contact with the heating body (3; 3a, 3b; 3a, 3c) or integrated in the heating body (3; 3a, 3b; 3a, 3c) or wherein the temperature regulating body (3; 3a, 3b; 3a, 3c) is a heating body adapted to be actively heated by a heater.

11. Measurement system according to one of the preceding claims, comprising one temperature sensor (2a) for capturing at least one temperature profile of the sample tissue (4) and a sensor of electromagnetic radiation (2c) for capturing in a different wavelength spectrum than the wavelength covered by the temperature sensor (2b) for gaining parameters of different depths of the tissue or for measuring reflectivity of the surface of the measurement area.

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12. Method for characterizing sample tissue in a non-invasive way by means of the measurement system (1) according to one of the preceding claims, comprising the following steps:

15 -setting a desired initial stimulation temperature of the at least one temperature regulating body (3; 3a, 3b; 3a, 3c), corresponding to a temperature of the at least one temperature regulating body (3; 3a, 3b; 3a, 3c) during a first contact of said temperature regulating body with the sample tissue (4; 4a, 4b), such that an initial temperature difference between said initial stimulation temperature and an initial tissue temperature is greater than zero,

20 - positioning the at least one temperature regulating body (3; 3a, 3b; 3a, 3c) on the sample tissue (4; 4a, 4b) such that it contacts the latter in the contact area (6), adjacent to the measurement area (5),

25 - positioning the temperature sensor (2; 2a, 2b) at a distance from the measurement area (5), wherein the distance is chosen such that substantially the entire measurement area (5) can be monitored by the temperature sensor (2; 2a, 2b),

30 - triggering capture of the temperature variations of the sample tissue by the temperature sensor (2; 2a, 2b) during the thermal stimulation of the sample tissue (4; 4a,

4b), wherein capture is performed at predefined time intervals and wherein

the at least one temperature regulating body (3; 3a, 3b; 3a, 3c) is in continuous contact with the sample tissue (4; 4a, 4b) in the contact area (6) during the entire measurement period, and

during the measurement period the at least one temperature regulating body (3; 3a, 3b; 3a, 3c) has a different temperature than the sample tissue (4; 4a, 4b), and

transferring a corresponding captured temperature profile for each capture to the computing unit (11),

- calculating at least one tissue characterizing parameter based on at least one of the captured temperature profiles by the computing unit (11) and outputting calculation results.

13. Method according to claim 12, wherein the capture of the temperature variations is ended either if a predefined time span has lapsed or if a current temperature difference between a current stimulation temperature and a current tissue temperature has reached a predefined threshold temperature difference.

14. Method according to claim 12 or 13, wherein the initial stimulation temperature of the at least one temperature regulating body (3; 3a, 3b; 3a, 3c) is chosen in such a way that the initial temperature difference between it and the initial tissue temperature is greater than a temperature resolution of the temperature sensor (2; 2a, 2b), particularly wherein the initial stimulation temperature is chosen in such a way that said initial temperature difference is at least 10 times greater than said temperature resolution of the temperature sensor (2;

2a, 2b), particularly wherein the initial temperature difference is of at least 0.5° C.

15. Method according to one of the claims 12 to 14,
5 wherein the tissue characterizing parameter or parameters are chosen to be one of or a combination of: a heat capacity of the sample tissue (4; 4a, 4b), a thermal conductivity of the sample tissue (4; 4a, 4b), a tissue density, a spatial location of an abrupt change in a
10 temperature distribution of the measurement area (5) or a tissue layer (4; 4a, 4b).

16. Method according to claim 15, wherein, in case two temperature regulating bodies (3a, 3b; 3a, 3c) are used,
15 the thermal conductivity of the sample tissue (4; 4a, 4b) is determined by adjusting the initial stimulation temperatures of the temperature regulating bodies (3a, 3b; 3a, 3c) in such a way that a value of the initial tissue temperature is between the two initial stimulation
20 temperatures of the temperature regulating bodies (3a, 3b; 3a, 3c), particularly in the middle of the two initial stimulation temperatures.

17. Method according to one of the claims 12 to 16,
25 wherein the characterizing parameter is calculated by the computing unit (11) by solving the heat equation, particularly wherein a thickness and/or a water content of at least one of the layers (4a, 4b) of the sample tissue (4) is calculated if the sample tissue (4) comprises more
30 than one layer.

18. Use of the measurement device according to one of the claims 1 to 11 for characterizing one or multiple

layers of skin (4; 4a, 4b), particularly a surface layer (4a) and/or a subjacent layer (4b) of the surface layer (4a), particularly wherein an ageing degree of the skin (4) is determined by measuring skin water content and thickness
5 of the epidermis (4a) as surface layer of the skin by deriving it from the at least one tissue characterizing.