CLAIMS

1. Device (1) for determination of a CO2 partial pressure value on a blood side (2) of an oxygenator (4), comprising:

- an oxygenator (4) with a blood side (2), a gas side (6) and a semipermeable membrane (8), wherein the membrane (8) separates the blood side (2) from the gas side (6), the gas side (6) has an inlet (14) and an outlet (16) and, during operation of the oxygenator (4), a gas flow flows into the inlet (14) to the outlet (16) at a flow rate;
- a first sensor (10) configured to measure CO2 partial pressure values of the gas side (6);
- a control unit (12) configured to process the measured CO2 partial pressure values of the gas side (6) and to determine a CO2 partial pressure value on the blood side (2) based on the measured CO2 partial pressure values of the gas side (6),

wherein the control unit (12) determines the CO2 partial pressure value on the blood side (2) during operation of the oxygenator (4) by calculating a change rate of the measured CO2 partial pressure values of the gas side (6), and, when or after the calculated change rate equals a predetermined change rate value or falls within a predetermined change rate range at a predetermined measuring distance, deducing the CO2 partial pressure value on the blood side (2) from the CO2 partial pressure values of the gas side (6) which are measured when or after the calculated change rate equals the predetermined change rate value or falls within the predetermined change rate range at the predetermined measuring distance.

2. Device (1) according to claim 1, wherein the change rate is a change rate over time and the predetermined measuring distance is a predetermined period of time.

3. Device (1) according to claim 1, wherein the device (1) comprises a second sensor (11) configured to measure CO2 partial pressure values of the gas side (6), and wherein the change rate is a change rate over location, the predetermined measuring distance is a predetermined local measuring distance and the first sensor (10) and the second sensor (11) are positioned at the predetermined local measuring distance.

4. Device (1) according to claim 2, wherein the control unit (12) is further configured to stop the gas flow into the inlet (14), and wherein the control unit (12) stops the gas flow into the inlet (14) before deducing the CO2 partial pressure value on the blood side (2), in particular before or during calculating the change rate of the measured CO2 partial pressure values of the gas side (6).

5. Device (1) according to claim 3, wherein the control unit (12) is further configured to adapt the flow rate of the gas flow into the inlet (14), and wherein the control unit (12) gradually reduces the flow rate of the gas flow into the inlet (14) until the change rate over location equals the predetermined change rate value or falls within the predetermined change rate range at the predetermined local measuring distance.

6. Device (1) according to claim 2 or 3, wherein the control unit (12) is further configured to adapt the flow rate of the gas flow into the inlet (14), and wherein the control unit (12) reduces the flow rate of the gas flow into the inlet (14) to a predetermined reduced gas flow rate before deducing the CO2 partial pressure value on the blood side (2), in particular before or during calculating the change rate of the measured CO2 partial pressure values of the gas side (6), wherein, for calculating the change rate, the CO2 partial pressure values of the gas side (6) are measured at a validated point or within a validated portion of the device (1), in particular of the gas side (6), for which validated point or validated portion it has been proven that the CO2 partial pressure of the gas side (6) reaches a saturation value at the predetermined reduced gas flow rate.

7. Device (1) according to claim 1 or 2, wherein:

- the gas side (6) is formed by a plurality of hollow fibers (26) through which the gas flows from the inlet (14) to the outlet (16), and the first sensor (10) is connected to the gas side (6) via only a part of the plurality of hollow fibers (26) of the gas side (6), preferably at a downstream end of the part of the plurality of hollow fibers (26) or downstream of the downstream end of the part of the plurality of hollow fibers (26);
- the first sensor (10) is configured to measure CO2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6);

- the control unit (12) is configured to process the measured CO2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side 6 and to determine a CO2 partial pressure value on the blood side (2) based on the measured CO2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6); and
- the control unit (12) determines the CO2 partial pressure value on the blood side (2) during operation of the oxygenator (4) by calculating a change rate of the measured CO2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6), and, when or after the calculated change rate equals a predetermined change rate value or falls within a predetermined change rate range at a predetermined measuring distance, deducing the CO2 partial pressure value on the blood side (2) from the CO2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6) which are measured when or after the calculated change rate equals the predetermined change rate value or falls within the predetermined change rate range at the predetermined measuring distance.

8. Device (1) according to claim 7, wherein a valve (28) is provided downstream of the first sensor (10), the valve (28) being configured to stop or reduce the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) in a first state and to release or increase the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) in a second state.

9. Device (1) according to claim 8, wherein:
- the change rate is a change rate over time and the predetermined measuring distance is a predetermined period of time; and
- the control unit (12) is configured to stop the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) by means of the valve (28), wherein the control unit (12) stops the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) before deducing the CO2 partial pressure value on the blood side (2), in particular before or during calculating the change rate of the measured

CO_2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6).

10. Device (1) according to claim 8, wherein:

- the change rate is a change rate over time and the predetermined measuring distance is a predetermined period of time; and
- the control unit (12) is configured to reduce the flow rate of the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) to a predetermined reduced gas flow rate by means of the valve (28) before deducing the CO_2 partial pressure value on the blood side (2), in particular before or during calculating the change rate of the measured CO_2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6), wherein, for calculating the change rate, a position at which the CO_2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6) are measured is a validated position within the device (1) for which it has been proven that the CO_2 partial pressure of the part of the plurality of hollow fibers (26) of the gas side (6) reaches a saturation value at the predetermined reduced gas flow rate.

11. Device (1) according to claim 4 or 5, wherein the control unit (12) is further configured to adapt the proportion of CO_2 in the gas flow, and wherein the control unit (12) increases the proportion of CO_2 in the gas flow up to a predetermined increased proportion of CO_2, in particular before the control unit (12) stops the gas flow or before, when or while the control unit (12) reduces the flow rate.

12. Device (1) according to claim 6, wherein the control unit (12) is further configured to adapt the proportion of CO_2 in the gas flow, and wherein the control unit (12) increases the proportion of CO_2 in the gas flow up to a predetermined increased proportion of CO_2 before deducing the CO_2 partial pressure value on the blood side (2), in particular before, when or after the control unit (12) reduces the flow rate to the predetermined reduced flow rate, and wherein for the validated point or validated portion it has been proven that the CO_2 partial pressure of the gas side (6) reaches the

saturation value at the predetermined reduced gas flow rate at the predetermined increased proportion of CO2.

13. Device (1) for determination of a CO2 partial pressure value on a blood side (2) of an oxygenator (4), comprising:

- an oxygenator (4) with a blood side (2), a gas side (6) and a semipermeable membrane (8), wherein the membrane (8) separates the blood side (2) from the gas side (6), the gas side (6) has an inlet (14) and an outlet (16) and, during operation of the oxygenator (4), a gas flow flows into the inlet (14) to the outlet (16) at a flow rate;
- a first sensor (10) configured to measure CO2 partial pressure values of the gas side (6);
- a control unit (12) configured to control the flow rate of the gas flow into the inlet (14) and to process the measured CO2 partial pressure values of the gas side (6) and to determine a CO2 partial pressure value on the blood side (2) based on the measured CO2 partial pressure values of the gas side (6),

wherein the control unit (12) determines the CO2 partial pressure value on the blood side (2) during operation of the oxygenator (4) by stopping the gas flow into the inlet (14), measuring at least one CO2 partial pressure value of the gas side (6) when a validated period of time after stopping the gas flow has lapsed, and deducing the CO2 partial pressure value on the blood side (2) from the at least one CO2 partial pressure value of the gas side (6) which is measured when the validated period of time has lapsed, for which validated period of time it has been proven that the CO2 partial pressure of the gas side (6) reaches a saturation value.

14. Device (1) for determination of a CO2 partial pressure value on a blood side (2) of an oxygenator (4), comprising:

- the oxygenator (4) comprising a blood side (2), a gas side (6) and a semipermeable membrane (8), wherein the membrane (8) separates the blood side (2) from the gas side (6), the gas side (6) has an inlet (14) and an outlet (16), a gas flow flows into the inlet (14) to the outlet (16) at a flow rate during operation of the oxygenator (4), and the gas side (6) is formed by a plurality of hollow fibers (26) through which the gas flows from the inlet (14) to the outlet (16);

- a first sensor (10) which is connected to a part of the plurality of hollow fibers (26) of the gas side (6), preferably at a downstream end of the part of the plurality of hollow fibers (26) or downstream of the downstream end of the part of the plurality hollow fibers (26), the first sensor (10) being configured to measure CO2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6);
- a valve (28) which is provided downstream of the first sensor (10), the valve (28) being configured to stop or reduce the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) in a first state and to release or increase the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) in a second state;
- a control unit (12) which is configured to control the flow rate of the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) by means of the valve (28), and to process the measured CO2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6) and to determine a CO2 partial pressure value on the blood side (2) based on the measured CO2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6),

wherein the control unit (12) determines the CO2 partial pressure value on the blood side (2) during operation of the oxygenator (4) by stopping the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) by means of the valve (28), measuring at least one CO2 partial pressure value of the part of the plurality of hollow fibers (26) of the gas side (6) when a validated period of time after stopping the gas flow has lapsed, and deducing the CO2 partial pressure value on the blood side (2) from the at least one CO2 partial pressure value of the part of the plurality of hollow fibers (26) of the gas side (6) which is measured when the validated period of time has lapsed, for which validated period of time it has been proven that the CO2 partial pressure of the part of the plurality of hollow fibers (26) of the gas side (6) reaches a saturation value.

15. Device (1) for determination of a CO2 partial pressure value on a blood side (2) of an oxygenator (4), comprising:

- an oxygenator (4) with a blood side (2), a gas side (6) and a semipermeable membrane (8), wherein the membrane (8) separates the blood side (2) from the gas side (6), the gas side (6) has an inlet (14) and an outlet (16) and, during operation of the oxygenator (4), a gas flow flows into the inlet (14) to the outlet (16) at a flow rate;
- a first sensor (10) configured to measure CO2 partial pressure values of the gas side (6);
- a control unit (12) configured to control the flow rate of the gas flow into the inlet (14) and to process the measured CO2 partial pressure values of the gas side (6) and to determine a CO2 partial pressure value on the blood side (2) based on the measured CO2 partial pressure values of the gas side (6),

wherein the control unit (12) determines the CO2 partial pressure value on the blood side (2) during operation of the oxygenator (4) by reducing the flow rate of the gas flow into the inlet (14) to a predetermined reduced gas flow rate, measuring at least one CO2 partial pressure value of the gas side (6) when a validated period of time after reducing the flow rate to the predetermined reduced flow rate has lapsed and at a validated point or within a validated portion of the device (1), in particular of the gas side (6), and deducing the CO2 partial pressure value on the blood side (2) from the at least one CO2 partial pressure value of the gas side (6) which is measured at the validated point or within the validated portion when the validated period of time has lapsed, for which validated period of time and validated point or validated portion it has been proven that the CO2 partial pressure of the gas side (6) reaches a saturation value.

16. Device (1) for determination of a CO2 partial pressure value on a blood side (2) of an oxygenator (4), comprising:
- the oxygenator (4) comprising a blood side (2), a gas side (6) and a semipermeable membrane (8), wherein the membrane (8) separates the blood side (2) from the gas side (6), the gas side (6) has an inlet (14) and an outlet (16), a gas flow flows into the inlet (14) to the outlet (16) at a flow rate during operation of the oxygenator (4), and the gas side (6) is formed by a plurality of hollow fibers (26) through which the gas flows from the inlet (14) to the outlet (16);
- a first sensor (10) which is connected to a part of the plurality of hollow fibers (26) of the gas side (6), preferably at a downstream end of the part of the plurality of

hollow fibers (26) or downstream of the downstream end of the part of the plurality of hollow fibers (26), the first sensor (10) being configured to measure CO2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6);

- a valve (28) which is provided downstream of the first sensor (10), the valve (28) being configured to stop or reduce the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) in a first state and to release or increase the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) in a second state;
- a control unit (12) which is configured to control the flow rate of the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) by means of the valve (28), and to process the measured CO2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6) and to determine a CO2 partial pressure value on the blood side (2) based on the measured CO2 partial pressure values of the part of the plurality of hollow fibers (26) of the gas side (6),

wherein the control unit (12) determines the CO2 partial pressure value on the blood side (2) during operation of the oxygenator (4) by reducing the flow rate of the gas flow through the part of the plurality of hollow fibers (26) of the gas side (6) and the first sensor (10) to the gas outlet (16) by means of the valve (28) to a predetermined reduced gas flow rate, measuring at least one CO2 partial pressure value of the part of the plurality of hollow fibers (26) of the gas side (6) when a validated period of time after reducing the flow rate to the predetermined reduced flow rate has lapsed and at a validated position, and deducing the CO2 partial pressure value on the blood side (2) from the at least one CO2 partial pressure value of the part of the plurality of hollow fibers (26) of the gas side (6) which is measured at the validated position when the validated period of time has lapsed, for which validated period of time and validated position it has been proven that the CO2 partial pressure of the plurality of hollow fibers (26) of the gas side (6) reaches a saturation value.

17. Device (1) according to any one of the claims 1 to 16, wherein the control unit (12) determines the CO2 partial pressure value on the blood side (2) at predetermined time intervals and/or when a predetermined operating condition occurs.

18. Device (1) according to any one of the claims 1 to 17, wherein the first sensor (10) is positioned inside the oxygenator (4) at the outlet (16) of the gas side (6) or downstream of the outlet (16).

19. Device (1) according to any one of the claims 3, 5, 6, 11, 12 and 17, wherein at least one of the first sensor (10) and the second sensor (11), preferably the first sensor (10) and the second sensor (11), is/are positioned inside the oxygenator (4).

20. Device (1) according to any one of the claims 1 to 6, 11 to 13, 15 and 17 to 19, wherein a main gas line (22) is provided downstream of the outlet (16) at the gas side (6) and a branch line (24) branches off from the main line (22), and wherein one of the first sensor (10) and the second sensor (11) is positioned on the branch line (24).

21. Device (1) according to any one of claims 7 to 10, 14 and 16 to 18, wherein the part of the plurality of hollow fibers (26) of the gas side (6), to which the first sensor (10) is connected, is located, in a flow direction of the blood flow through the blood side (2), at the blood inlet (18).

22. Device (1) according to any one of claims 7 to 10, 14 and 16 to 18, wherein the part of the plurality of hollow fibers (26) of the gas side (6), to which the first sensor (10) is connected, is located, in a flow direction of the blood flow through the blood side (2), at the blood outlet (20).

23. Extracorporeal membrane oxygenation system comprising a device (1) according to any one of the claims 1 to 22.

24. Extracorporeal membrane oxygenation system according to claim 23, wherein the extracorporeal membrane oxygenation system is a veno-venous extracorporeal membrane oxygenation system.

25. Extracorporeal membrane oxygenation system according to claim 23, wherein the extracorporeal membrane oxygenation system is a veno-arterial extracorporeal membrane oxygenation system.

26. Cardiopulmonary bypass system comprising a device (1) according to any one of the claims 1 to 22.