

Flow field plate and compressor comprising such plate

The invention relates to a flow field plate for a solid-state compressor cell. The invention further relates to a solid-state compressor and a compressor cell for
5 electrochemically compressing a working fluid, comprising such a plate. In addition, the invention relates to a method for manufacturing such a plate assembly.

Where conventional mechanical compressors utilize mechanical means such as pistons or rotors for the compression of a fluid, solid-state compressors rely on the
10 electrochemical transport of said fluid through a membrane using an ionic transport mechanism. In order to compress the working fluid in an electrochemical manner, a solid-state compressor typically comprises a compressor cell that is made up of one or more stacked membrane electrode assemblies (also known as MEA's). The electrodes of the MEA are connected to a power supply for maintaining an electric
15 potential difference across the electrodes. This potential difference is necessary to electrochemically move the ionized working fluid through the proton exchange membrane (commonly known as a PEM) against the pressure gradient that exists across the membrane. The direction of the electrical current hereby determines the direction of the ionic transport, wherein the low-pressure working fluid is ionized at
20 the positively charged anode and recombined with the separated electrons at the high-pressure cathode side of the MEA.

A commonly known solid-state compressor is the electrochemical hydrogen compressor wherein hydrogen is fed to the membrane electrode assembly and
25 oxidized to protons and electrons. The protons are then driven through the membrane and the electrons are transferred via an external circuit, after which the protons and electrons are reduced back to molecular hydrogen. In this process, the hydrogen moves against a pressure gradient from an area of low pressure to an area of high pressure, resulting in the pressure rise across the membrane. The
30 compression of other working fluids, such as water or ammonia are however also possible.

Solid-state compressors have several significant advantages over mechanical compressors. Namely, solid-state compressors have no moving parts, generally
35 have a compact design and are capable of purifying the working fluid as the membrane typically allows for the transport of the ionized working fluid only.

Moreover, solid-state compressors allow fluids to be compressed to very large pressures up to and above 1000 bar at operating efficiencies exceeding those of mechanical compressors.

5 In the process of compressing the working fluid it is desired to obtain the highest gain per volume unit of the compressor. For that reason, a high efficiency for each MEA is required. One of the factors that determines the efficiency is the distribution of the gas in the MEA. This distribution is determined for an important amount by the flow field plates. The better the distribution, the higher the efficiency. However,
10 it has appeared that the flow field plates according to the state of the art do not have an optimal gas distribution. It is therefore a goal of the present invention to provide improved flow field plates, and a compressor comprising such improved flow field plates.

15 The invention hereto proposes a flow field plate for a solid state compressor cell, comprising an essentially flat body having two opposite surfaces and an edge, provided with a channel plan for gas distribution, that extends from multiple locations at a border of the field plate to multiple locations at the surface of the essentially flat body wherein the essentially flat body is provided with recesses at
20 both sides, the recesses at each side comprising a first set of parallel lanes, crossing a second set of parallel lanes.

It has appeared that a flow field plate comprising such channel plan has an increased distribution of the gas flow toward and from the membrane surface,
25 which leads to a higher flow rate and a better use of the available membrane surface. Due to its architecture, the channel plan further decreases the mechanical resistance the gas undergoes, which further improves the performance of the compressor.

30 In a further embodiment of the flow field plate according to the invention claims the flat body comprises through holes, extending from the first surface to the second surface. Herewith the flow and distribution are further improved, and the mechanical resistance the gas undergoes further decreased. In particular a flow in both all directions of the plane, and the direction perpendicular thereto is allowed
35 herewith.

In yet a further embodiment, the essentially flat body has a maximum thickness, defined as the length of a straight line from the one surface to the other surface, but less than 50 % of the essentially flat body has this maximum thickness. At locations
5 where the thickness is less than the maximum thickness, space for gas flow is available at the surface.

The flow field plate according to the invention may be formed out of multiple parts. This allows to create forms that cannot be achieved by state of the art techniques
10 like etching, and – given the extreme small size of the recesses, channels and openings – also not yet by techniques like 3D printing. In particular two parts of the essentially flat body besides a recess may be separate parts.

The invention also relates to a solid state compressor cell, comprising two cell
15 plates, enclosing a channel structure, formed by a number of recesses provided on a surface of one of the cell plates, used for the transport of a coolant and connecting a fluid feed on one end thereof and to a fluid discharge on another end thereof; and comprising a number of recesses provided on the outer surfaces of the cell plates facing away from the other cell plate, comprising at least two field plates
20 as described above, positioned on the recessed outer surfaces of the cell plates to form further channel structures for supplying a working fluid to respectively diverting a working fluid away from a proton exchange membrane.

These field plates may be clamped between the cell plates together with the
25 membrane, or diffusion-bonded with the cell plates. In any case, it is desired that the cell plates and the membrane are sealed in a fluid-tight manner.

It is also possible that the channel structure is configured for supplying a working fluid to or diverting a working fluid away from a proton exchange membrane. The
30 channel structure may hereto connect directly to the membrane assembly, in a typical case consisting of a proton exchange membrane, on both sides sandwiched between a catalyst layer and optionally a gas diffusion layer. Alternatively, the channel structure may connect to a further channel structure provided in a further cell plate or flow plate, or enclosed between one of the two cell plates and said
35 further cell plate or flow plate. In the direction of the plane, the size of the holes

may preferably be between 10 and 240 micron, in the direction perpendicular it may be between 1 and 200 micron.

- A thus formed flow plate has appeared to be mechanically sufficiently strong to
- 5 withstand the forces in a compressor. Preferably the flow plate is made at least locally elastically deformable, in order to compensate for irregularities in the thickness of the membrane of the cell plates.

Claims

1. Flow field plate for a solid-state compressor cell, comprising:
 - an essentially flat body,
 - 5 ▪ having two opposite surfaces and an edge;
 - provided with a channel plan for gas distribution, that extends from multiple locations at a border of the field plate to multiple locations at the surface of the essentially flat body;
- characterized in that**
 - 10 - the essentially flat body is provided with recesses at both sides, the recesses at each side comprising a first set of parallel lanes, crossing a second set of parallel lanes.
2. Flow field plate according to any of the preceding claims, wherein the flat
15 body comprises through holes, extending from the first surface to the second surface.
3. Flow field plate according to any of the preceding claims, wherein the essentially flat body has a maximum thickness, defined as the length of a straight
20 line from the one surface to the other surface, wherein less than 50 % of the essentially flat body has the maximum thickness.
4. Flow field plate according to any of the preceding claims, formed out of multiple parts.
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5. Flow field plate according to claim 4, wherein two parts of the essentially flat body besides a recess are separate parts.
6. Flow field plate according to claim 2 wherein the through holes have a size
30 between 1 and 200 micron.
7. Flow field plate according to any of the preceding claims comprising holes in the direction of the plane, having a size between 10 and 240 micron.

8. Flow field plate according to any of the preceding claims wherein the flow field plate is at least partially elastic.
9. Solid state compressor cell, comprising:
- 5 ○ two cell plates, enclosing a channel structure, formed by a number of recesses provided on a surface of one of the cell plates, used for the transport of a coolant and connecting a fluid feed on one end thereof and to a fluid discharge on another end thereof; and comprising a number of recesses provided on the outer surfaces of the cell plates facing away from
- 10 the other cell plate;
- at least two flow field plates according to any of the preceding claims, positioned on the recessed outer surfaces of the cell plates to form further channel structures for supplying a working fluid to, respectively diverting a working fluid away from, a proton exchange membrane;
- 15 ○ said proton exchange membrane.
10. Solid State compressor cell according to claim 8, wherein the field plates are clamped between the cell plates together with the membrane.
- 20 11. Solid State compressor cell according to claim 8, wherein the field plates are diffusion-bonded with the cell plates.
12. Solid State compressor cell according to any of the preceding claims, wherein the field, the cell plates and the membrane are sealed in a fluid-tight
- 25 manner.