CLAIMS

1. A bipolar plate comprising:

a unitary body having:

a first surface;

a second surface, the second surface being opposite the first surface;

a primary zone, the primary zone defining a first plane;

a border, the border being continuous along an entire perimeter of the primary zone, the border extending away from the primary zone to form a flange wholly disposed on a second plane, the second plane being parallel to and axially spaced apart from the first plane to define a full height between the first plane and the second plane;

two or more apertures including an inlet and an outlet, both the inlet and the outlet being defined in the primary zone at one of the first surface and the second surface;

a plurality of channel elements, the plurality of channel elements being formed wholly in the primary zone and characterized by the full height relative to the first plane, at least one of the plurality of channel elements at least partially defines a planar flow path extending from the inlet to the outlet, the planar flow path being disposed on the first plane; and

an aperture wall partially disposed about each of the two or more apertures, wherein each of the two or more apertures extends through a thickness of the unitary body between a first opening defined in the primary zone at the first surface and a second opening defined in the primary zone at the second surface, and wherein the aperture wall disposed at the first opening forms a corresponding recessed element at the second surface, the recessed element being partially disposed about the second opening.

2. The bipolar plate as recited in claim 1, wherein the planar flow path is defined by a flow height relative to the first plane, the flow height being a uniform full height from the inlet to the outlet.

3. The bipolar plate as recited in claim 1, wherein another aperture wall disposed at the second opening forms another corresponding recessed element at the first surface.

4. The bipolar plate as recited in claim 1,

wherein a first aperture wall is spaced apart from the first opening to define an inner flow zone therebetween,

and wherein the first aperture wall is spaced apart from the border to define an outer flow zone therebetween, the first aperture wall defining a slot channel in fluid communication with the inner flow zone and the outer flow zone, the slot channel being characterized by the full height.

5. The bipolar plate as recited in claim 1, wherein the plurality of channel elements further comprises one or more first guide channels extending at the first surface between two selected ones of the two or more apertures, and wherein the one or more guide channels form a corresponding one or more second guide channels extending at the second surface between another two selected ones of the two or more apertures.

6. The bipolar plate as recited in claim 1, wherein the bipolar plate is characterized by a rotational symmetry of order two, the rotational symmetry being defined relative to an axis normal to the first plane.

7. A module, comprising:

a plurality of bipolar plates, each of the plurality of bipolar plates being a unitary body having:

a first surface;

a second surface, the second surface being opposite the first surface;

a primary zone, the primary zone defining a first plane;

a border, the border being continuous along an entire perimeter of the primary zone, the border extending away from the primary zone to form a flange wholly disposed on a second plane, the second plane being parallel to and axially spaced apart from the first plane to define a full height between the first plane and the second plane;

a plurality of apertures being defined in the primary zone and non-contiguous with the border, each of the plurality of apertures providing fluidic communication through a thickness of the unitary body between the first surface and the second surface; and

a plurality of channel elements, the plurality of channel elements being formed wholly in the primary zone and characterized by the full height relative to the first plane to at least partially define a planar flow path from one of the plurality of apertures to another of the plurality of apertures along one of the first surface and the second surface, the plurality of channel elements being non-contiguous with the border,

wherein the plurality of bipolar plate are stacked together along an axis normal to the first plane,

wherein each of the two or more apertures extends between a first opening defined in the primary zone at the first surface and a second opening defined in the primary zone at the second surface, and

wherein the plurality of channel elements comprises a first of an aperture wall at the first surface, the first of the aperture wall being partially disposed about the first opening of a selected aperture, and

wherein the first of the aperture wall forms a corresponding first of a recessed element at the second surface, the first of the recessed element being partially disposed about the second opening of the selected aperture, the selected aperture being one selected from the two or more apertures.

8. The module as recited in claim 7, the plurality of channel elements further comprising a second of the recessed element at the first surface, the second of the recessed element forms a corresponding second of the aperture wall at the second surface.

9. The module as recited in claim 7,

wherein the first of the aperture wall is spaced apart from the first opening to define an inner flow zone therebetween,

and wherein the first of the aperture wall is spaced apart from the border to define an outer flow zone therebetween, the first of the aperture wall defining a slot channel in fluid communication with the inner flow zone and the outer flow zone, the slot channel having the full height.

10. The module as recited in claim 9, wherein the plurality of channel elements further comprises one or more first guide channels extending at the first surface between two selected ones of the two or more apertures, and wherein the one or more guide channels form a corresponding one or more second guide channels extending at the second surface between another two selected ones of the two or more apertures.

11. The module as recited in any one of claims 7 to 10,

wherein the plurality of apertures comprises a pair of cathode inlet/outlet in fluid communication with only one of the first surface and the second surface of a selected one of the plurality of bipolar plates,

and wherein the plurality of apertures comprises a pair of anode inlet/outlet in fluid communication with only another of the first surface and the second surface of the selected one of the plurality of bipolar plates.

12. The module as recited in any one of the claims 7 to 10, wherein the plurality of apertures comprises:

a pair of cathode inlet/outlet;

a pair of anode inlet/outlet; and

a pair of coolant inlet/outlet, wherein the pair of coolant inlet/outlet is in fluid communication with one of the first surface and the second surface of a selected one of the plurality of bipolar plates, and wherein another of the first surface and the second surface is in fluid communication with one of the pair of cathode inlet/outlet and the pair of anode inlet/outlet.

13. The module as recited in any one of claims 7 to 12, wherein each of the plurality of bipolar plates is characterized by a rotational symmetry of order two, the rotational symmetry being defined relative to a normal axis, the normal axis being defined by the first plane.

14. A fuel cell comprising one or more of the modules as recited in any one of claims 7 to 13, the one or more modules being axially assembled to one another.

15. A method of forming the bipolar plate of any one of claims 1 to 6, comprising:

stamping a metal blank in a first direction to form the primary zone, the primary zone being displaced by a full height relative to an unstamped area; and

stamping the primary zone in a second direction to form one or more channel elements nested in the primary zone, each of the one or more channel elements being displaced by the full height relative to the primary zone.