

CLAIMS

1. A water polishing system comprising:

a connection to a source of ultrapure water (UPW) comprising particles having a diameter less than 30 nm;

an ultrafiltration (UF) module having an inlet and a permeate outlet;

a vibration source operatively coupled to the UF module, the vibration source, when in use, increasing efficiency of a membrane of the UF module to retain the particles having the diameter less than 30 nm from UPW being filtered by applying vibrations to the UF module during filtration of the UPW;

a recirculation conduit communicating the permeate outlet with the inlet and forming a recirculation loop;

a recirculation pump disposed along the recirculation conduit upstream from the inlet of the UF module and fluidly coupled to the source of UPW;

~~a supply conduit fluidly coupled to the recirculating conduit and a demand source, the supply conduit positioned downstream from the permeate outlet; and~~

a pressure control valve disposed along the recirculation conduit downstream from and directly fluidly coupled to a demand source, the supply conduit and pressure control valve configured to maintain a constant pressure of the permeate at a predetermined value and maintain a constant flux through the UF module, the pressure control valve being controlled based on at least a pressure signal indicative of a pressure of the permeate within the recirculation conduit;

a pressure sensor positioned along the recirculation conduit upstream of the pressure control valve and configured to generate the pressure signal indicative of the pressure of the permeate; and

a controller operatively coupled to the pressure sensor and configured to control operation of the pressure control valve based on the pressure signal.

~~2. — The water polishing system of claim 1, further comprising a pressure sensor positioned along the recirculation conduit between the supply conduit and the pressure control valve, configured to generate a pressure signal indicative of a pressure of the permeate.~~

3. ~~The water polishing system of claim 2, further comprising a controller operatively coupled to the pressure sensor and configured to control operation of the pressure control valve based on the pressure signal.~~

5 42. The water polishing system of claim 31, further comprising:
a UPW make-up conduit fluidly coupled to the source of UPW and the recirculation conduit; and
a blending point where the UPW make-up conduit fluidly connects to the recirculation conduit such that the pressure control valve is positioned between the blending point and the
10 pressure sensor, and the controller is configured to operate the pressure control valve such that the pressure of the permeate is maintained at a predetermined pressure value.

53. The water polishing system of claim 42, wherein the recirculation pump is positioned downstream from the blending point such that a fluid including UPW and permeate is delivered
15 to the recirculation pump at the predetermined pressure value.

64. The water polishing system of claim 53, wherein the recirculation pump is configured to operate at a predetermined constant speed.

20 75. The water polishing system of claim 53, wherein the UF module further includes a reject outlet for retentate from the UF module and a reject conduit fluidly coupled to the reject outlet.

6. The water polishing system of claim 1, further comprising a holding tank disposed along the recirculation conduit.

25 7. The water polishing system of claim 1, wherein the vibration source produces vibrations in a frequency range of about 20 Hz to about 1000 Hz.

8. The water polishing system of claim 1, wherein the controller is further operable to adjust a speed of the recirculation pump based on a temperature signal indicative of a temperature of the permeate.

9. The water polishing system of claim 1, wherein the controller is further operable to adjust the pressure control valve based on a temperature signal indicative of a temperature of the permeate.

10. The water polishing system of claim 1, further comprising a supply conduit fluidly coupled to the recirculating conduit and the demand source, the supply conduit positioned downstream from the permeate outlet.

11. The water polishing system of claim 10, wherein the pressure control valve is positioned downstream from the supply conduit.

12. The water polishing system of claim 10, wherein the demand source comprises a semiconductor manufacturing tool.

~~8. The water polishing system of claim 1, further comprising a vibration source coupled to the UF module.~~

~~9. A method of treating water, comprising:~~

~~receiving a flow of ultrapure water (UPW) directed toward a recirculation pump from a source of UPW;~~

~~setting the speed of the recirculation pump to a predetermined constant speed;~~

~~directing a fluid including the UPW to an inlet of an ultrafiltration (UF) module;~~

~~recirculating at least a portion of permeate from a permeate outlet of the UF module to the inlet using the recirculation pump and a recirculation conduit;~~

~~providing a valve arrangement actuatable from a closed to an open condition for effecting pressure of permeate to the recirculation pump;~~

measuring a pressure of the permeate at a position that is upstream from the valve arrangement and downstream from the permeate outlet;

comparing the measured pressure of the permeate to a predetermined value; and
responsive to the comparison, actuating the valve arrangement.

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10. — The method of claim 9, wherein the valve arrangement is actuated to maintain a substantially constant transmembrane pressure (TMP) across a UF membrane of the UF module.

11. — The method of claim 9, further comprising combining the flow of UPW with permeate at a blending point positioned along the recirculation conduit such that the valve arrangement is positioned upstream from the blending point.

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12. — The method of claim 11, further comprising providing a supply conduit to a demand source along the recirculation conduit at a position upstream from the pressure measurement position and downstream from the permeate outlet.

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13. — The method of claim 9, wherein the recirculation pump is configured to deliver the fluid to the UF module at a pressure that is greater than the predetermined value.

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14. — The method of claim 9, further comprising applying a vibration to the UF module.

15. — A method of facilitating polishing of ultrapure water (UPW), comprising:

— providing an ultrafiltration (UF) module having an inlet and a permeate outlet; and

— providing instructions to:

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— connect the permeate outlet to the inlet;

connect the permeate outlet to a pressure control valve; and

maintain a pressure of permeate exiting the permeate outlet at a predetermined value with the pressure control valve.

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16. — The method of claim 15, further comprising providing instructions to:

connect a recirculation pump to the inlet of the UF module;
blend the permeate with a source of UPW to form a fluid; and
— direct the fluid to an inlet of the recirculation pump.

5 17. — The method of claim 16, further comprising instructions to:
connect the permeate outlet to a demand source; and
measure a pressure of the permeate using a pressure sensor prior to blending with the
source of UPW.

10 18. — The method of claim 17, further comprising providing a controller that is configured to
be operatively coupled to the pressure sensor and the pressure control valve.

15 19. — The method of claim 18, further comprising providing control instructions to the
controller to compare a measured pressure of the permeate to a predetermined value and,
responsive to the comparison, actuate the pressure control valve.

20 20. — The method of claim 19, wherein the control instructions instruct the controller to actuate
the pressure control valve to maintain a substantially constant transmembrane pressure (TMP)
across a UF membrane of the UF module.

21. — The method of claim 16, further comprising providing at least one of the recirculation
pump and the pressure control valve.

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