ELECTRODIALYSIS SYSTEMS AND METHODS FOR ENERGY GENERATION AND WASTE TREATMENT

FIELD OF THE TECHNOLOGY

One or more aspects relate generally to waste treatment. More particularly, one or more aspects relate to systems and methods for generating energy while treating waste.

BACKGROUND

Large quantities of acidic and alkaline materials are used in various industries. For example, wafer cleaning is the most frequently repeated step in integrated circuit manufacturing and is one of the most important segments in the semiconductor equipment business. The processes are getting more complicated as device sizes shrink and new materials are used. Some representative acids and bases which are commonly used in such cleaning processes include hydrochloric acid, sulfuric acid, hydrofluoric acid and ammonium hydroxide. A representative semiconductor fabrication plant may consume or at least purchase about 70 to 80 tons of 50% sodium hydroxide solution monthly to neutralize acid wastes. In chemical etching, acids or bases are used to dissolve unwanted materials such as metals, semiconductor materials or glass. The common acids and bases used as etchants include hydrochloric acid, nitric acid, hydrofluoric acid, sodium hydroxide and potassium hydroxide. Mining waste is also an issue.

Acidic and caustic waste effluents are typically treated via a neutralization process prior to disposal. Precipitation and filter press may also be used in treatment. The neutralization process must be carefully controlled due to the exothermic reaction of acids and bases. Several attempts have been proposed to recover or recycle acids and bases such as by diffusion dialysis, ion exchange, low pressure distillation and solvent extraction, but industrial application of such approaches has been very limited to date.

SUMMARY

In accordance with one or more embodiments, reverse electrodialysis system may comprise an anode, a cathode, a load in electric communication with the anode and the cathode, a first chamber, positioned between the anode and the cathode, bounded by a first ion exchange membrane and a bipolar membrane, the first chamber being in fluid communication with an acidic waste effluent stream, and a second chamber, positioned between the anode and the cathode, bounded by the bipolar membrane and a second ion

CLAIMS

1. A reverse electrodialysis system, comprising:

an anode;

a cathode;

a load in electric communication with the anode and the cathode;

a first chamber, positioned between the anode and the cathode, bounded by a first ion exchange membrane and a bipolar membrane, the first chamber being in fluid communication with an acidic waste effluent stream;

a second chamber, positioned between the anode and the cathode, bounded by the bipolar membrane and a second ion exchange membrane, the second chamber being in fluid communication with a caustic waste effluent stream; and a third chamber, positioned between the anode and the cathode, bounded by the second ion exchange membrane and a third ion exchange membrane, the third chamber being in fluid communication with a salt solution source;

wherein the system is constructed and arranged to mix the acidic waste effluent stream at an outlet of the first chamber with the caustic waste effluent stream at an outlet of the second chamber to form one salt solution source.

2. The system of claim 1, further comprising a recycle system configured to recirculate the acidic waste effluent stream to the first chamber.

3. The system of claim 2, wherein the recycle system is further configured to recirculate the caustic waste effluent stream to the second chamber.

4. The system of claim 1, wherein the system is constructed and arranged to neutralize the acidic and caustic waste effluent streams while converting their chemical energy to electric energy.

5. The system of claim 4, wherein the converted electric energy is harnessed by the load.

6. The system of claim 1, wherein the acidic waste effluent comprises hydrochloric acid.

7. A method of treating effluent waste, comprising:

providing a reverse electrodialysis system;

fluidly connecting a source of acidic waste effluent to a first chamber of the reverse electrodialysis system;

fluidly connecting a source of caustic waste effluent to a second chamber of the reverse electrodialysis system;

fluidly connecting a source of salt solution to a third chamber of the reverse electrodialysis system;

collecting a neutralized effluent stream at an outlet of the reverse electrodialysis system;

delivering the neutralized effluent stream to the third chamber of the reverse electrodialysis system; and

providing a load between an anode and a cathode of the reverse electrodialysis system to harness electric energy.

8. The method of claim 7, wherein fluidly connecting the sources of acidic and caustic waste effluent comprises fluidically coupling a semiconductor fabrication operation to the reverse electrodialysis system.

9. The method of claim 8, further comprising recycling the acidic waste effluent to the first chamber.

10. The method of claim 7, further comprising recycling the caustic waste effluent to the second chamber.

11. The method of claim 7, further comprising discharging the neutralized effluent stream.

12. The method of claim 11, further comprising treating the neutralized effluent stream prior to discharge.

13. The method of claim 7, further comprising adjusting an electric resistance of the load.

14. A reverse electrodialysis system, comprising:

an anode;

a cathode;

a load in electric communication with the anode and the cathode;

a first chamber, positioned between the anode and the cathode, bounded by a first ion exchange membrane and a simulated bipolar membrane comprising a cation exchange membrane coupled to an ion exchange membrane, the first chamber being in fluid communication with an acidic waste effluent stream;

a second chamber, positioned between the anode and the cathode, bounded by the simulated bipolar membrane and a second ion exchange membrane, the second chamber being in fluid communication with a caustic waste effluent stream; and

a third chamber, positioned between the anode and the cathode, bounded by the second ion exchange membrane and a third ion exchange membrane, the third chamber being in fluid communication with a salt solution source;

wherein the salt solution source comprises a mixture of the acidic waste effluent stream exiting the first chamber and the caustic effluent stream exiting the second chamber.

15. A reverse electrodialysis system, comprising:

an anode;

a cathode;

a load in electric communication with the anode and the cathode;

a first chamber, positioned between the anode and the cathode, bounded by a first ion exchange membrane and a second ion exchange membrane, the first chamber being in fluid communication with an acidic waste effluent stream and a salt solution source;

a second chamber, positioned between the anode and the cathode, bounded by the second ion exchange membrane and a third ion exchange membrane, the second chamber being in fluid communication with the salt solution source;

a third chamber, positioned between the anode and the cathode, bounded by the third ion exchange membrane and a fourth ion exchange membrane, the third chamber being in fluid communication with the with a caustic waste effluent stream and the salt solution source; and

a fourth chamber, positioned between the anode and the cathode, bounded by the fourth ion exchange membrane and a fifth ion exchange membrane, the fourth chamber being in fluid communication with the salt solution source;

wherein the salt solution source comprises a mixture of the acidic waste effluent stream exiting the first chamber and the caustic effluent stream exiting the third chamber.

REVERSE ELECTRODIALYSIS SYSTEMS AND METHODS FOR ENERGY GENERATION AND WASTE TREATMENT

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SUMMARY

In accordance with one or more embodiments, reverse electrodialysis system may comprise an anode, a cathode, a load in electric communication with the anode and the cathode, a first chamber, positioned between the anode and the cathode, bounded by a first ion exchange membrane and a bipolar membrane, the first chamber being in fluid communication with an acidic waste effluent stream, and a second chamber, positioned between the anode and the cathode, bounded by the bipolar membrane and a second ion

CLAIMS

1. A reverse electrodialysis system, comprising:

an anode;

a cathode;

a load in electric communication with the anode and the cathode;

a first chamber, positioned between the anode and the cathode, bounded by a first ion exchange membrane and a bipolar membrane, the first chamber being in fluid communication with an acidic waste effluent stream;

a second chamber, positioned between the anode and the cathode, bounded by the bipolar membrane and a second ion exchange membrane, the second chamber being in fluid communication with a caustic waste effluent stream; and a third chamber, positioned between the anode and the cathode, bounded by the second ion exchange membrane and a third ion exchange membrane, the third chamber being in fluid communication with a salt solution source; and

a recycle system configured to recirculate the acidic waste effluent stream to the first chamber;

wherein the system is constructed and arranged to mix the acidic waste effluent stream at an outlet of the first chamber with the caustic waste effluent stream at an outlet of the second chamber to form one salt solution source.

2. The system of claim 1, wherein the recycle system is further configured to recirculate the caustic waste effluent stream to the second chamber.