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KELP-INSPIRED MARINE ENERGY CONVERTER

Abstract

A kelp-inspired marine energy converter (MEC) device having a plurality of strips of flexible electroactive materials connected to a power conditioning module and anchored to a structure (such as the ocean floor) is described. The movement of the strips caused by water motion or current action (i.e., water motion) converted by the electroactive material to electrical energy.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application claims priority to U.S. Provisional Patent Application No. 63/489,454 filed on Mar. 10, 2023, the contents of which are incorporated herein by reference in their entirety.

BACKGROUND

[0003] Most ocean wave energy conversion technologies are extremely large, mostly rigid, monolithic structures that usually harness one type of current energy (e.g., surging, heaving, etc.) using a single power take-off system. Many traditional wave energy conversion technologies include rotating machinery or components, which can be damaged by entanglement, over-speeding, debris collisions, and/or tip-to-tower strikes. Thus, there remains a need for flexible, lightweight, and relatively durable marine energy converters.

SUMMARY

[0004] An aspect of the present disclosure is a device for generating electrical energy from a water motion, the device including a strip having a first end and a second end, and a power conditioning module connected to the first end, in which the strip comprises an electroactive material and a conductive material, and the device is configured to generate electrical energy when exposed to water motion through a movement of the electroactive material in response to the water motion. In some embodiments, the device also includes at least one buoyancy device. In some embodiments, the buoyancy device includes at least one of a gas, cork, foam, or sponge. In some embodiments, the device also includes an anchor connected to the first end, in which the anchor connects the device to a structure. In some embodiments, the structure includes at least one of a rock, an ocean floor, a post, a column, or a coral. In some embodiments, the structure includes at least one of a substrate, backing, mesh, mooring line, a buoy, or a floating solar device. In some embodiments, the device also includes a protective material positioned around the strip. In some embodiments, the protective material comprises at least one of polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), or silicone. In some embodiments, the power conditioning module includes at least one of a rectifier, diode, transformer, inverter, or power converter. In some embodiments, the strip is configured to generate an alternating current (AC), and the power conditioning module is configured to convert the AC to a direct current (DC). In some embodiments, the electroactive material includes at least one of polyvinylidene fluoride (PVDF), lead zirconate titanate (PZT), or zinc oxide. In some embodiments, the conductive material includes at least one of copper, gold, tin, or silver. In some embodiments, the mesh includes at least one of a natural fiber, nylon, polyester, twine, polypropylene, or polyethylene.

[0005] An aspect of the present disclosure is a system including: a first device for generating an electrical energy from a water motion, a second device for generating the electrical energy from the water motion, and a mesh, in which: the first device includes: a first strip having a first end and a second end, and a first power conditioning module connected to the first end, in which the first strip includes an electroactive material and a conductive material, and the first device is configured to generate the electrical energy when exposed to the water motion through the movement of the electroactive material, the second device includes: a second strip having a third end and a fourth end, and a second power conditioning module connected to the third end, in which the second strip comprises an electroactive material and a conductive material, and the second device is configured to generate the electrical energy when exposed to the water motion through the movement of the electroactive material, the mesh is connected to the first end and the third end, and the mesh is connected to a structure. In some embodiments, the first device also includes at least one buoyancy device. In some embodiments, the buoyancy device includes at least one of a gas, cork, foam, or sponge. In some embodiments, the first strip is configured to generate an alternating current (AC),

and the first power conditioning module is configured to convert the AC to a direct current (DC). In some embodiments, the electroactive material includes at least one of polyvinylidene fluoride (PVDF), lead zirconate titanate (PZT), or zinc oxide. In some embodiments, the conductive material includes at least one of copper, gold, silver, or tin. In some embodiments, the mesh includes at least one of a natural fiber, nylon, polyester, twine, polypropylene, or polyethylene.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Some embodiments of the present disclosure are illustrated in the referenced figures of the drawings. It is intended that the embodiments and figures disclosed herein are to be considered illustrative rather than limiting.

[0007] FIG. 1 illustrates an electroactive marine energy converter (MEC), according to some aspects of the present disclosure.

[0008] FIG. 2 illustrates a system of a plurality of electroactive MECs, according to some aspects of the present disclosure.

[0009] FIG. 3A illustrates a plurality of electroactive MECs including buoyancy devices and FIG. 3B illustrates an exemplary single electroactive MEC having a buoyancy device, according to some aspects of the present disclosure.

[0010] FIG. 4 illustrates measured voltage generation in response to water motion for four exemplary electroactive MECs, according to some aspects of the present disclosure.

REFERENCE NUMERALS

[0011] **100** . . . device [0012] **105** . . . strip [0013] **110** . . . first end [0014] **115** . . . second end [0015] **120** . . . power conditioning module [0016] **125** . . . electroactive material [0017] **130** . . . conductive material [0018] **135** . . . buoyancy device [0019] **140** . . . anchor [0020] **145** . . . structure [0021] **150** . . . protective material

DETAILED DESCRIPTION

[0022] The embodiments described herein should not necessarily be construed as limited to addressing any of the particular problems or deficiencies discussed herein. References in the specification to “one embodiment”, “an embodiment”, “an example embodiment”, “some embodiments”, etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0023] As used herein the term “substantially” is used to indicate that exact values are not necessarily attainable. By way of example, one of ordinary skill in the art will understand that in some chemical reactions 100% conversion of a reactant is possible, yet unlikely. Most of a reactant may be converted to a product and conversion of the reactant may asymptotically approach 100% conversion. So, although from a practical perspective 100% of the reactant is converted, from a technical perspective, a small and sometimes difficult to define amount remains. For this example of a chemical reactant, that amount may be relatively easily defined by the detection limits of the instrument used to test for it. However, in many cases, this amount may not be easily defined, hence the use of the term “substantially”. In some embodiments of the present invention, the term “substantially” is defined as approaching a specific numeric value or target to within 20%, 15%, 10%, 5%, or within 1% of the value or target. In further embodiments of the present invention, the term “substantially” is defined as approaching a specific numeric value or target to within 1%,

0.9%, 0.8%, 0.7%, 0.6%, 0.5%, 0.4%, 0.3%, 0.2%, or 0.1% of the value or target.

[0024] As used herein, the term “about” is used to indicate that exact values are not necessarily attainable. Therefore, the term “about” is used to indicate this uncertainty limit. In some embodiments of the present invention, the term “about” is used to indicate an uncertainty limit of less than or equal to $\pm 20\%$, $\pm 15\%$, $\pm 10\%$, $\pm 5\%$, or $\pm 1\%$ of a specific numeric value or target. In some embodiments of the present invention, the term “about” is used to indicate an uncertainty limit of less than or equal to $\pm 1\%$, $\pm 0.9\%$, $\pm 0.8\%$, $\pm 0.7\%$, $\pm 0.6\%$, $\pm 0.5\%$, $\pm 0.4\%$, $\pm 0.3\%$, $\pm 0.2\%$, or $\pm 0.1\%$ of a specific numeric value or target.

[0025] Among other things, the present disclosure relates to a kelp-inspired marine energy converter (MEC) device having a plurality of strips of flexible electroactive materials connected to a power conditioning module and anchored to a structure (such as the ocean floor). The movement of the strips caused by water motion or current action (i.e., water motion) converted by the electroactive material to electrical energy.

[0026] Note that electroactive MEC device of the present disclosure may be utilized in any aquatic environment, such as under the ocean (at various depths ranging from substantially shallow to the deep sea), rivers, streams, or lakes. As described herein, the electroactive MEC device may be attached to the floor or bed of the aquatic environment it is operated in, a natural feature of the aquatic environment, a man-made feature of the aquatic environment, or an object that is capable of movement (either active or by floating) throughout the aquatic environment (at the surface level or submerged).

[0027] FIG. 1 illustrates a kelp-inspired MEC device **100**, according to some aspects of the present disclosure. A MEC device **100** may include at least one strip **105** which has a first end **110** and a second end **115**. The strip **105** may be made of an electroactive material **125** and a conductive material **130**. A buoyancy device **135** may be connected to the second end **115**. A power conditioning module **120** may be connected to the first end **110**. An anchor **140** may connect the first end **110** to a structure **145**. A protective material **150** may be positioned around the strip **105**. A sealant **155** may connect the protective material **150** to the strip **105**.

[0028] In some embodiments, the strip **105** may be designed to mimic the appearance of sea grass or kelp. The strip **105** may be substantially planar. In some embodiments, the strip **105** may have a length (i.e., the distance between the first end **110** and the second end **115**) in the range of about 6 inches to about 5 feet (60 inches) and a width in the range of about 0.5 inch to about 12 inches. In some embodiments, the strip **105** may have a width in the range of approximately 0.5 inch to approximately 3.5 inches. The strip **105** may have a thickness in the range of about 10 μm to about 500 μm . In some embodiments, the strip **105** may have a thickness in the range of about 50 μm to about 150 μm .

[0029] In some embodiments, a MEC device **100** may have more than one strip **105** connected to a single power conditioning module **120** and/or a single anchor **140**. In some embodiments, a single MEC device **100** may have two (2), three (3), four (4), five (5), six (6), seven (7), eight (8), nine (9), ten (10) or more strips **105**. In some embodiments, the strip **105** may have branches (i.e., not be substantially rectangular) and the electroactive material **125** and/or the conductive material **130** may not be in a single linear orientation but may have multiple sections all originating from the first end **110**.

[0030] In some embodiments, the strip **105** may include a substantially electroactive material **125** (i.e., a material capable of converting mechanical stress/movement to electrical energy). The electroactive material **125** may be substantially planar and substantially rectangular. Exemplary electroactive materials **125** include piezoelectric materials such as at least one of polyvinylidene fluoride (PVDF), lead zirconate titanate (PZT), or zinc oxide. In some embodiments, the electroactive material **125** may include elastomer generators, dielectric elastomer generators, or magnetostrictive generators. In some embodiments, the electroactive material **125** may be substantially poled (i.e., have a positive surface and a negative surface).

[0031] In some embodiments, the strip **105** may also include a conductive material. The conductive material may be substantially planar and rectangular or may be substantially cylindrical. Exemplary conductive materials **130** may include at least one of copper, gold, tin, or silver. The electroactive material **125** and the conductive material **130** may be substantially parallel along the strip **105**. In some embodiments, the conductive material **130** may include a first electrode and a second electrode. In some embodiments, the first electrode may be connected to the positive surface of the electroactive material and the second electrode may be connected to the negative surface of the electroactive material.

[0032] In some embodiments, each strip may be connected to at least one buoyancy device **135**. A buoyancy device **135** may be made of a material that is substantially less dense than water. In some embodiments, the buoyancy device **135** may be substantially hollow (i.e., filled with a gas, such as at least one of air, nitrogen, helium, oxygen, or argon). Exemplary buoyancy devices include a ping pong ball, a cork, foam, or a sponge. Buoyancy devices **135** may be connected to the strips **105** at various points along the length of an individual strip. In some embodiments, the buoyancy device **135** may be located at or near the second end **115**.

[0033] In some embodiments, the first end **110** may be connected to an anchor **140**. The anchor **140** may be a wire, tether, rope, chain, or other mooring device which connects the MEC device **100** to a structure **145**. In some embodiments, the structure **145** may be substantially stationary, such as a rock, the ocean floor, a post, a column, or coral. In some embodiments, the structure **145** may be floating on the water, suspended in the water (i.e., at least partially submerged), and/or connected to a solid object, but still capable of some movement, such as a mooring line, a buoy, a floating solar device or other sensor/instrument, or autonomous underwater vehicle (AUV). The MEC device **100** may be connected to a variety of submerged or partially submerged structures **145**, for example, a pier, a dock, a floating solar cell, a mooring line, a buoy, the ocean floor, an AUV recharging station, an electric boat charging station, an AUV, an offshore fixed-bottom wind turbine, an offshore floating wind turbine, an offshore oil and gas platform, coral, an artificial reef structure, a rock, or other submerged structure. In some embodiments, the anchor **140** may be connected to a mesh **205** (as shown in FIG. 2). In some embodiments, the anchor **140** may have a length between the structure **145** and the strip **105**. The length may be in the range of about 0.5 inches to about 5 feet (60 inches).

[0034] In some embodiments, a power conditioning module **120** may be connected to the first end **110** of the electroactive MEC **100**. The power conditioning module **120** may be at least one of a rectifier, diode, transformer, inverter, or power converter. The electroactive material **125** of the electroactive MEC **100** is capable of converting movement (i.e., kinetic energy) into electrical energy, but the resulting electrical energy may be in the form of an alternating current (AC). The power conditioning module **120** may be capable of converting the AC power to direct current (DC). In some embodiments, the power conditioning module **120** may also include an energy storage capability, such as a battery, fuel cell, or energy storage media.

[0035] In some embodiments, the strip **105** may be surrounded by a protective material **150**. Exemplary protective materials include at least one of polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), or silicone. In some embodiments, the protective material **150** may substantially enclose, surround, or envelop the strip **105**. The protective material **150** may substantially watertight around the strip **105**.

[0036] In some embodiments, the protective material **150** may be connected to the electroactive material **125** and the conductive material **130** using a sealant **155**. Exemplary sealant **155** materials include a plastic bond, Loctite marine caulk, epoxy, vacuum sealant tape, silicone caulk, rubber cement, and/or a glue or heat gun paste. The sealant **155** may assist the protective material **150** in creating a substantially watertight seal around the strip **105**. The sealant **155** may connect the electroactive material **125**, conductive material, and/or protective material **150** together.

[0037] FIG. 2 illustrates a system **200** of a plurality of electroactive MECs **100**, according to some

aspects of the present disclosure. A group of electroactive MECs **100** may be connected using a mesh **205**. In FIG. 2, not all electroactive MECs **100** are shown in detail, some are indicated by a circle labeled as the electroactive MEC **100**. This was to avoid a chaotic image. A weight (not shown) may be connected to the mesh **205** to act as an anchor **140** for the system **200**.

[0038] In some embodiments, water motion/movement may result in nutrients being “trapped” or more concentrated around the strips **105** and/or mesh **205**. For example, the mesh **205** may accumulate sediment on the ocean floor. In some embodiments, a system **200** including a plurality of electroactive MECs **100** connected by a mesh **205** may be utilized for both electrical energy generation and erosion control/sediment control. When a plurality of electroactive MECs are connected to a mesh, they may be arranged in a substantially grid-like formation, circular formation, or other geographic 1-D (i.e., a line) or 2-D (i.e., a grid) orientation.

[0039] In some embodiments, the mesh **205** may be a netting, fabric, or other substantially flexible material. The mesh **205** may be made of a natural fiber, nylon, polyester, twine, polypropylene, polyethylene, yarn, wire, stainless steel, or other material. The mesh **205** may connect multiple electroactive MECs **100** to each other and to at least one structure **205**. In some embodiments, the mesh **205** may contain a wire or other means of electrically connecting the electroactive MECs **100** to at least one power conditioning module **120**.

[0040] In some embodiments, the weight (not shown) connected to the mesh **205** may be made of iron, steel, stainless steel, plastic, rubber, cement, gravel, and/or another material that is substantially denser than water. The weight and/or the anchor **140** may serve to keep the mesh **205** from being moved significantly by water movement, allowing the mesh **205** to remain substantially stationary while the strips **105** are moved by water movement. In some embodiments, the structure **145** may be the weight.

[0041] FIG. 3A illustrates a system **200** including a plurality of strips **105** and buoyancy devices **135** and FIG. 3B illustrates an electroactive MEC **100** having a single strip **105** having a single buoyancy device **135**, according to some aspects of the present disclosure. As shown in FIG. 3A, a single strip **105** may be connected to any number of buoyancy devices **135**, in the range of one (1) to ten (10) positioned along the length of the strip **105**. The images as shown in FIG. 3A-B show exemplary systems **200** and electroactive MECs **100** as used for testing. Each exemplary electroactive MECs **100** as shown in FIG. 3A-B was made using a strip **105** of an electroactive material of polyvinylidene fluoride (PVDF) and a conductive material of copper (Cu). The buoyancy devices **135** in FIG. 3A-B were substantially hollow and substantially spherical (i.e., ping pong balls). The electroactive MECs **100** were connected to a power conditioning module **120** of an inverter.

[0042] FIG. 4 illustrates measured average voltage generation in response to water motion for four exemplary electroactive MECs **100**, according to some aspects of the present disclosure. The four electroactive MECs **100** shown in FIG. 4 include: Frond.sub.1(23) which was approximately 44 inches long, Frond.sub.2(14) which was approximately 68 inches long, Frond.sub.3(12) which was approximately 52 inches long, and Frond.sub.4(5) which was approximately 60 inches long. The electroactive MECs **100** tested for the results in FIG. 4 included an electroactive material **125** of polyvinylidene fluoride (PVDF) and a conductive material **130** of copper (Cu). The results shown in FIG. 4 demonstrate that electrical energy (as measured in mV) was generated by the electroactive MECs **100** when exposed to different wave heights (measured in mm) and periods (as measured in seconds) as shown on the x-axis. The voltage shown in FIG. 4 may be generated by the electroactive MEC **100** from wave movement on the electroactive material **125** and the conductive material **130** creating electrical energy in the form of alternating current (AC) and the power conditioning module **120** receiving the AC electrical energy and converting it to direct current (DC).

[0043] In some embodiments, the electroactive MEC **100** may be manufactured by first cutting the electroactive material **125** into its desired shape (including length, width, and/or thickness). Next,

the conductive material **130** may be adhered (using the sealant **155** or any adhered manufacturing process or method) to both the first (i.e., positive) surface and the second (i.e., negative) surface of the electroactive material **125**. In some embodiments, the conductive material **130** may be substantially equivalent in length to the electroactive material **125**. Next, a positive wire may be attached (e.g., soldered) to the first electrode and a negative wire may be attached to the second electrode. The positive and negative wires may be of substantially the same material as the conductive material **130** or may be an electrical wire. Next, the strip **105** of both the electroactive material **125** and the conductive material **130** may be coated (via submersion, applying/painting, deposition, and/or other means) with the protective material **150**. Any gaps, joints, edges, seams, or other desired portions of the protective material may be further made substantially watertight by applying the sealant **155**. Next, the electroactive MEC **100** may be tested by attaching the first electrode and the second electrode (and their respective wires) to a voltage measurement device (e.g., a voltmeter, a multimeter, or an oscilloscope), manually stimulating the electroactive MEC **100**, and verifying the electrical output. Finally, the protective material **150** and sealant **155** may be tested by submerging the electroactive MEC **100** in water and monitoring for air bubbles, then removing the electroactive MEC **100** and checking for any water located inside the electroactive MEC **100**.

EXAMPLES

[0044] Example 1. A device for generating electrical energy from a water motion, the device comprising: [0045] a strip having a first end and a second end; and [0046] a power conditioning module connected to the first end; wherein: [0047] the strip comprises an electroactive material and a conductive material, and [0048] the device is configured to generate electrical energy when exposed to water motion through a movement of the electroactive material in response to the water motion.

[0049] Example 2. The device of Example 1, further comprising: [0050] at least one buoyancy device.

[0051] Example 3. The device of Example 2, wherein: [0052] the buoyancy device is located at or near the second end.

[0053] Example 4. The device of Example 2, wherein: [0054] the buoyancy device comprises a material that is substantially less dense than water.

[0055] Example 5. The device of Example 4, wherein: [0056] the material comprises at least one of air, cork, foam, or sponge.

[0057] Example 6. The device of Example 1, further comprising: [0058] an anchor connected to the first end.

[0059] Example 7. The device of Example 6, wherein: [0060] the anchor connects the device to a structure.

[0061] Example 8. The device of Example 7, wherein: [0062] the structure comprises at least one of a rock, an ocean floor, a post, a column, or a coral.

[0063] Example 9. The device of Example 7, wherein: [0064] the structure comprises at least one of a mooring line, a buoy, or a floating solar device.

[0065] Example 10. The device of Example 1, wherein: [0066] the strip is substantially planar.

[0067] Example 11. The device of Example 1, further comprising: [0068] a protective material positioned around the strip.

[0069] Example 12. The device of Example 11, wherein: [0070] the protective material comprises at least one of polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), or silicone.

[0071] Example 13. The device of Example 1, wherein: [0072] the power conditioning module comprises at least one of a rectifier, diode, transformer, inverter, or power converter.

[0073] Example 14. The device of Example 1, wherein: [0074] the strip is configured to generate an alternating current (AC), and [0075] the power conditioning module is configured to convert the AC to a direct current (DC).

[0076] Example 15. The device of Example 1, wherein: [0077] the electroactive material comprises at least one of polyvinylidene fluoride (PVDF), lead zirconate titanate (PZT), or zinc oxide.

[0078] Example 16. The device of Example 1, wherein: [0079] the conductive material comprises at least one of copper, gold, or silver.

[0080] Example 17. The device of Example 1, wherein: [0081] the conductive material comprises a first electrode and a second electrode, [0082] the first electrode comprises a first wire, and [0083] the second electrode comprises a second wire.

[0084] Example 18. The device of Example 17, wherein: [0085] the first wire and the second wire comprise at least one of copper, gold, or silver

[0086] Example 19. A system comprising: [0087] a first device for generating an electrical energy from a water motion; [0088] a second device for generating the electrical energy from the water motion; and [0089] a mesh; wherein: [0090] the first device comprises: [0091] a first strip having a first end and a second end; and [0092] a first power conditioning module connected to the first end; wherein: [0093] the first strip comprises an electroactive material and a conductive material, and [0094] the first device is configured to generate the electrical energy when exposed to the water motion through the movement of the electroactive material, [0095] the second device comprises: [0096] a second strip having a third end and a fourth end; and [0097] a second power conditioning module connected to the third end; wherein: [0098] the second strip comprises an electroactive material and a conductive material, and [0099] the second device is configured to generate the electrical energy when exposed to the water motion through the movement of the electroactive material, [0100] the mesh is connected to the first end and the third end, and [0101] the mesh is connected to a structure.

[0102] Example 20. The system of Example 19, wherein: [0103] the structure comprises at least one of a rock, an ocean floor, a post, a column, or a coral.

[0104] Example 21. The system of Example 19, wherein: [0105] the structure comprises at least one of a mooring line, a buoy, or a floating solar device.

[0106] Example 22. The system of Example 19, wherein: [0107] the first device further comprises: [0108] at least one buoyancy device located at or near the second end.

[0109] Example 23. The system of Example 22, wherein: [0110] the buoyancy device comprises a material that is substantially less dense than water.

[0111] Example 24. The system of Example 23, wherein: [0112] the material comprises at least one of air, cork, foam, or sponge.

[0113] Example 25. The system of Example 19, wherein: [0114] the first strip is substantially planar.

[0115] Example 26. The system of Example 19, wherein: [0116] the first device further comprises: [0117] a protective material positioned around the first strip.

[0118] Example 27. The system of Example 26, wherein: [0119] the protective material comprises at least one of polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), or silicone.

[0120] Example 28. The system of Example 19, wherein: [0121] the first power conditioning module comprises at least one of a rectifier, diode, transformer, inverter, or power converter.

[0122] Example 29. The system of Example 19, wherein: [0123] the first strip is configured to generate an alternating current (AC), and [0124] the first power conditioning module is configured to convert the AC to a direct current (DC).

[0125] Example 30. The system of Example 13, wherein: [0126] the electroactive material comprises at least one of polyvinylidene fluoride (PVDF), lead zirconate titanate (PZT), or zinc oxide.

[0127] Example 31. The system of Example 19, wherein: [0128] the conductive material comprises at least one of copper, gold, silver, or aluminum.

[0129] Example 32. The system of Example 19, wherein: [0130] the conductive material comprises a first electrode and a second electrode, [0131] the first electrode comprises a first wire, and [0132]

the second electrode comprises a second wire.

[0133] Example 33. The system of Example 32, wherein: [0134] the first wire and the second wire comprise at least one of copper, gold, silver, or aluminum.

[0135] Example 34. The system of Example 19, wherein: [0136] the first strip has a length between the first end and the second end, and [0137] the first electrode and the second electrode are substantially parallel to the length.

[0138] Example 35. The system of Example 19, wherein: [0139] the mesh comprises at least one of nylon, polyester, twine, polypropylene, or polyethylene.

[0140] The foregoing discussion and examples have been presented for purposes of illustration and description. The foregoing is not intended to limit the aspects, embodiments, or configurations to the form or forms disclosed herein. In the foregoing Detailed Description for example, various features of the aspects, embodiments, or configurations are grouped together in one or more embodiments, configurations, or aspects for the purpose of streamlining the disclosure. The features of the aspects, embodiments, or configurations may be combined in alternate aspects, embodiments, or configurations other than those discussed above. This method of disclosure is not to be interpreted as reflecting an intention that the aspects, embodiments, or configurations require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment, configuration, or aspect. While certain aspects of conventional technology have been discussed to facilitate disclosure of some embodiments of the present invention, the Applicants in no way disclaim these technical aspects, and it is contemplated that the claimed invention may encompass one or more of the conventional technical aspects discussed herein. Thus, the following claims are hereby incorporated into this Detailed Description, with each claim standing on its own as a separate aspect, embodiment, or configuration.

Claims

1-20. (canceled)

21. A device for generating electrical energy from a water motion, the device comprising: a strip comprising an electroactive material, and a conductive material; and a power conditioning module; wherein: the electroactive material comprises at least one of polyvinylidene fluoride (PVDF), lead zirconate titanate (PZT), or zinc oxide, the conductive material is connected to the power conditioning module, and the device is configured to generate electrical energy when exposed to the water motion through a movement of the electroactive material in response to the water motion.

22. The device of claim 21, wherein: the strip has a first end, and the first end is connected to an anchor.

23. The device of claim 22, wherein: the anchor is connected to an autonomous underwater vehicle (AUV).

24. The device of claim 22, wherein: the anchor is connected to a sensor or an instrument.

25. The device of claim 22, wherein: the anchor is connected to a structure, and the structure is floating on a body of water.

26. The device of claim 25, wherein: the structure comprises a floating solar device or an AUV.

27. The device of claim 21, wherein: the electroactive material comprises at least one of polyvinylidene fluoride (PVDF), lead zirconate titanate (PZT), or zinc oxide.

28. The device of claim 21, wherein: the conductive material comprises at least one of copper, gold, or silver.

29. The device of claim 21, wherein: the power conditioning module comprises at least one of a rectifier, diode, transformer, inverter, or power converter.

30. The device of claim 21, wherein: the first strip is configured to generate an alternating current (AC), and the first power conditioning module is configured to convert the AC to a direct current

(DC).

31. The device of claim 21, wherein: the power conditioning module comprises a battery.

32. The device of claim 21, further comprising: a protective material positioned around the strip.

33. The device of claim 32, wherein: the protective material comprises at least one of polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), or silicone.

34. The device of claim 21, further comprising: at least one buoyancy device.

35. The device of claim 34, wherein: the buoyancy device comprises at least one of air, cork, foam, or sponge.

36. The device of claim 21, further comprising: a second strip; wherein: the second strip comprises the electroactive material, and the conductive material.

37. The device of claim 36, wherein: the electroactive material comprises at least one of polyvinylidene fluoride (PVDF), lead zirconate titanate (PZT), or zinc oxide.

38. The device of claim 36, wherein: the conductive material comprises at least one of copper, gold, or silver.

39. The device of claim 36, further comprising: a protective material positioned around the strip.

40. The device of claim 39, wherein: the protective material comprises at least one of polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), or silicone.
