Supporting Information

A Highly Adaptive Real-Time Water Wave Sensing Array for Marine Applications

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1. The voltage and induced voltage vary with the size of the single component.

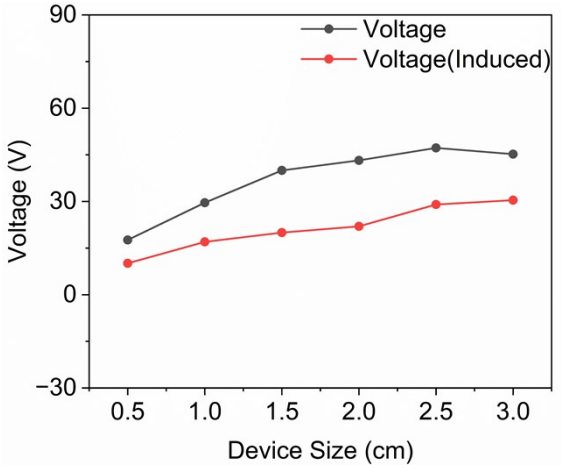

Figure S1. The voltage and induced voltage vary with the size of the single component.

In figure S1, the voltage and induced voltage values are the average of the peak values in figure 4a, and they vary with the single component size.

2. Endurance test figures for 2000s of continuous operation and 3h underwater operation of a single component.

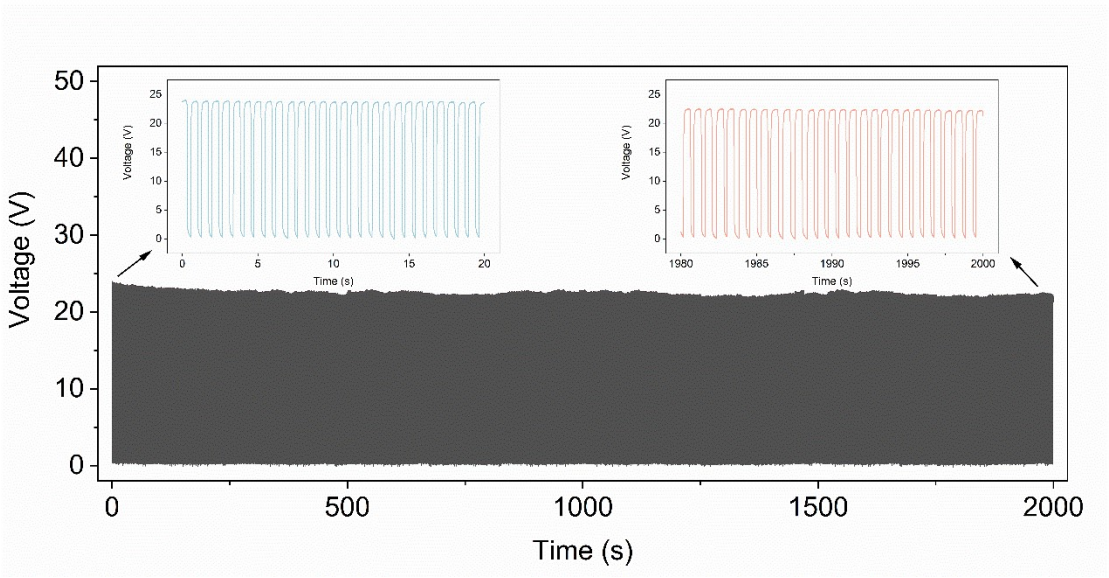

Figure S2. The performance of the induction electrode of a 1.5×1.5cm single component for 2000s of continuous operation.

We tested the performance of the induction electrode of a 1.5×1.5cm single component for 2000s of continuous operation and found that there was a negligible attenuation, which basically could be maintained in the best working condition, proving the reasonableness of the overall structural design of the device and the ability of its parts to work in practice.

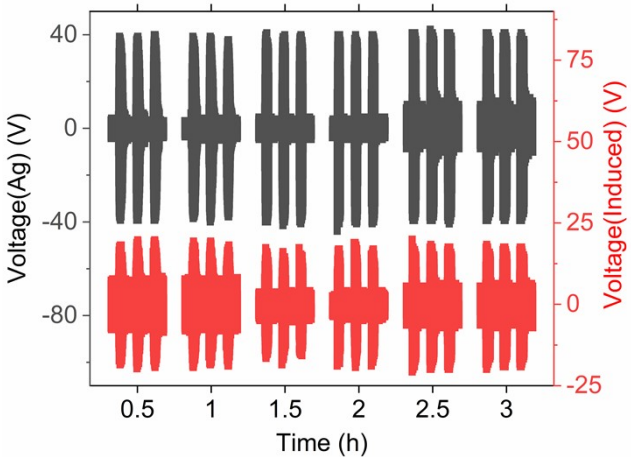

Figure S3. Durability test of single component double-layer silver electrode working underwater for 3h.

We used a 1.5×1.5cm unit and tested its ability to work continuously underwater for 3h. The result shows that both layers of silver electrodes have long durability underwater without significant performance degradation.

3. Display the pressure information of 6×4 sensing array on a curved surface. (MP4)

4. Display the palm sliding information of 6×4 water wave sensing array. (MP4)

5. A detailed description of the signal flow process that senses and

distinguishes the specific form of water waves in this system.

The sensing principle of water wave friction is to judge the height of the water level by the row electrode first, and then combine the timing signal characteristics of the column electrode peak for fine to each cell point output state judgment, and then restore the image display for visual mapping. The processing logic of this program is based on the motion in the vertical direction. Due to the motion characteristics of the water wave, its impact on the device will first rub upward and then fade downward, mainly in the vertical direction, our horizontal-vertical design of the array just use the motion characteristics of the water wave in the vertical direction to build the sensing program.

It first relies on horizontally connected row electrodes to sense the water level height. The output peak shape generated by the water wave friction has sufficient amplitude between the peak and the noise to set the threshold for triggering the peak-seeking process, and when the circuit collects the periodic output signal, a series of processing will be performed, including noise reduction, filtering, amplifying the effective signal, addressing the peak-seeking, etc. The peak-seeking process includes a mechanism specifically written for determining the peak shape to find the real output peak that matches the characteristics of the water wave, and the peak-seeking characteristics of different working environments may be different. The specific programming details have considered the length of the intercepted signal period, which is not affected by the actual period of the waves, and each time the signal of half a period or several periods of the waves can be taken for peak-seeking judgment, which ensures the practicality of the system and the diversity of working environments.

However, if we rely only on the row electrode, as any point in a line with water friction will show the output of the whole line, that is, indicating that the water level has reached a certain height, but the actual water wave may vary in shape, not stable over the level or not straight state, then it is necessary to combine the timing characteristics of the inductor electrode behind the row (i.e. column electrode) to make a specific judgment of a single point. If the signal received from the inductor column can be judged as a valid output timing characteristic peak after signal processing and the unique judgment mechanism of the column electrode, then this point is confirmed to be triggered. The judgment mechanism of the column electrode signal combines peak-seeking and peak pattern recognition, and also takes advantage of the feature that the water wave is moving mainly in the vertical direction: the signal of the inductor column will have different degree of spreading depending on the friction time, regardless of the state of the water wave friction in the vertical direction. Because the

water wave and the array continue to friction, there must be more than equal to one column of inductor electrodes will continue to generate induction signal, continuous generation of induction signal will lead the peak shape from each peak is very significant such as sharp, narrow, etc. to high output time is lengthened and the peak shape becomes gentler, that is, the peak has a broadened form. Depending on the length of the friction time, the degree of broadening varies, and the periods will also be staggered, so the timing characteristics of the column electrode peaks can be used as a condition to specifically determine the output of the unit point or not. Therefore, the system can accurately identify and restore the entire array in the vertical direction, whether it is a one-way slide from one side to the other, or repeatedly rubbing back and forth inside the array, beyond the array.

In general, the whole process of judging the signal of water wave friction is as follows: first, the range and size of the output signal of the row electrode determine the range of water waves passing through, then combine with the signal peak characteristics of the induction column electrode below the row electrode to determine the location of the specific points participating in friction, and finally, the set of points participating in friction is used as the basis for the terminal waveform display image, and a separate image conversion program is used to restore the waveform.

6. Use the 6×4 sensing array to monitor water wave motion in real-time and achieve marine warning. (MP4)