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Electrical Energy form Rising Air Bubbles

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Extended Abstract

Technologies to harvest electrical energy from waste micro mechanical energy sources have gained considerable attention due to self-powered technology. Different energy sources and energy conversion methods are essential not only for large scale but also for micro/nano scale for self-powered sensors, wearable devices and wireless networks. A few methods have been developed in last decades for conversion of ambient energy to electrical energy such as piezoelectric, photovoltaics and triboelectric methods [1-3]. Moreover, contact electrification of liquid-solid interface has become a promising energy harvesting method due to its simple fabrication steps, durability and capability to operate without external bias energy.

In this study, we demonstrate a rising air bubble converts its energy to electrical energy while rising beneath a hydrophobic strip shaped electrodes. The two electrode system under water can be represented as two serially connected electrical double layer (EDL) capacitors[4]. Adsorption and desorption of the ions take place when a bubble rises beneath the hydrophobic surface due to formation of three phase contact line. As a result, EDL capacitors asymmetrically charge and discharge producing voltage deference between two electrodes.

We compared the output energy of this bubble motion active transducer (BMAT) with the similar system using a descending water droplet called water motion active transducer (WMAT)[5]. Energy conversion efficiency of BMAT is remarkably higher compared to WMAT. WMAT converts about seven time larger energy than water droplet due to the differences in contact area, moving speed, deformation of the bubble and multiple peak outputs from a single bubble[6].

Surface charge density on the hydrophobic surface is a critical factor for energy conversion. In this experiment we increased the surface charge density by exposing the surface to argon plasma. Enhancement of surface charge density takes place due to braking bonds and formation of free radicals on the surface. This is confirmed by measuring the water contact angle and electrostatic potential on the hydrophobic surface. The contact angle decreases from the initial value of 119.7° to 108.2° and the surface potential from -2.4 V to -4.3 V. After the plasma treatment, BMAT converted 70 nJ from a single air bubble, which is about 18 times higher than the fresh surface.

Finally, we demonstrated the multi-electrodes based BMAT for effective harvesting of energy from rising air bubbles. Multiple current outputs produced by a single air bubble results in higher energy conversion efficiencies. The output energy strongly depends on the way of end connection of the multi-electrodes system. Interdigital electrodes (IDEs) based BMAT and individual rectified multi-electrodes (IRMEs) based BMAT are remarkably different in terms of their energy output. Even though both the systems produce multiple current outputs, energy converted by IDEs based BMAT decreases with the increasing the number of electrodes due to the effect of total area. In contrast, in the IRMEs BMAT the energy linearly increases with the increasing the number of electrodes. This is further confirmed by charging a capacitor and also by lighting a LED using different number of multi-electrodes BMATs.

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