THE MICROFLUIDIC ENERGY CONVERSION BY DROPLETS

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The rapid economic development and increasing consumption of electrical energy requires people to generate more energy. The new energy sources developed are required to be clean and environmentally friendly. Microfluidic energy harvesting device is relatively less known compared with other popular renewable energy sources, such as solar cell and bio-fuels, but can provide such a clean and environmentally-friendly source.

The classical electrokinetic energy conversion mechanism relies on a single stage conversion by forcing liquid through a channel with charged walls. When the net charges inside the electrical double layer (EDL) are transported by water flow, the produced electrical energy can be harvested via connection of electrodes at two ends of a channel.

Different from traditional single phase flow energy conversion, the liquid microjet was used for energy conversion. Applied pressure forces water flow through a micropore, forming a liquid jet. Then the jet broke into droplets, which are absolutely isolated by air. Droplet kinetic energy is converted to electrical energy when the charged droplets decelerate in the electrical field that forms between membrane and target. It operates entirely different with traditional energy conversion from streaming potential, hence we term it “ballistic energy conversion”. Conversion occurs in two stages: first pressure is converted to kinetic energy and subsequently kinetic energy is converted to electrical energy. In the first stage a stream of high-velocity high-charge droplets is produced by forcing water through a micropore. In the second stage the charged droplets travel through an electrical field towards a high-potential target, decelerating them to zero speed. The target acquires its potential by droplet impact. Current is drawn from the target to do useful work. We strongly reduced loss factors by optimizing the setup from the physical model. At present this resulted in an energy conversion efficiency of almost 50% with as main loss factor hydrodynamic friction losses in the micropore.

Now, inspired by Kelvin’s water dropper, we apply the electrostatic charge self-induction mechanism to an inertia-driven (ballistic) energy conversion system, and show the disadvantages of Kelvin’s water dropper do not any more apply. The droplet charge thereby is derived from the same inductive charging mechanism as in Kelvin’s droplet generator, employing two separate systems and cross-connecting targets and induction rings. To prevent overcharging of the droplets by the inductive mechanism and consequent droplet loss by repulsion from the target, we use voltage dividers, trying both a resistor divider and a diode divider, to enable stable energy conversion with a self-induction system. The current rapidly increased once the electrical circuit was connected. With reversely connected diodes, the induction voltage could be properly controlled to a saturated value (about 500V), whereby experimentally maximal 17.9% energy conversion efficiency was obtained with the diode-induced system.

Word Count: 448

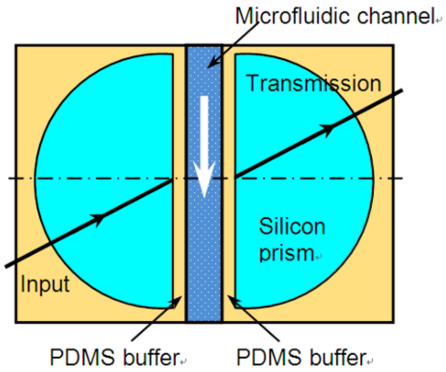


Fig.1 Schematic diagram of the microfluidic planar reactor and structures of the catalyst film and the tree-shaped microchannels for inlet and outlet.

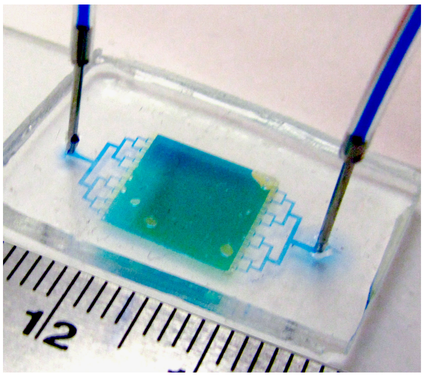


Fig. 2Photograph of the microfluidic planar reactor integrated with the inlet and the outlet.

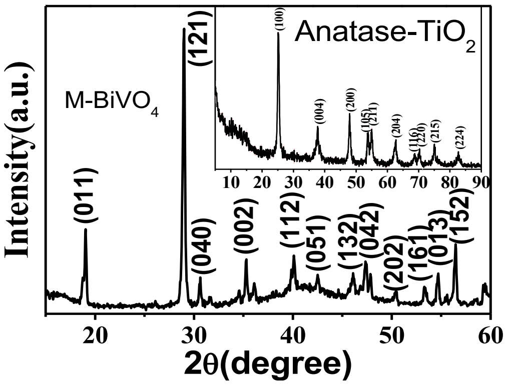


Fig. 3 Characteristics of the photocatalytic films: XRD patterns of the layers of BVOand TiO_2(inset). The BVO layer shows a monoclinic structure and the TiO_2 is in pure anatase phase.

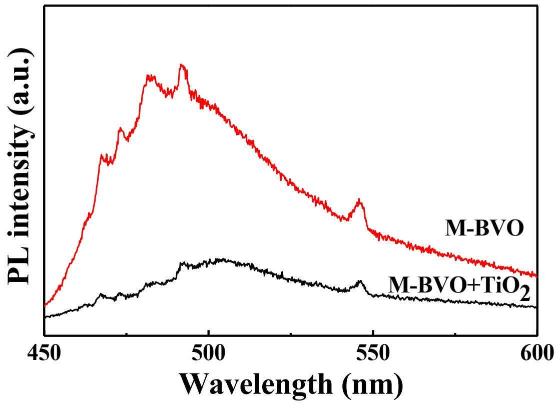
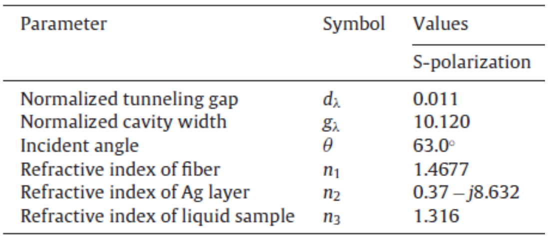


Fig. 4Characteristics of the photocatalytic films: Photoluminescence of M-BVO and BVO/TiO_2.

Table 1. Sample of a Table Format



Parameter	Symbol	Values
		S-polarization
Normalized tunneling gap	d_λ	0.011
Normalized cavity width	g_λ	10.120
Incident angle	θ	63.0°
Refractive index of fiber	n_1	1.4677
Refractive index of Ag layer	n_2	$0.37 - j8.632$
Refractive index of liquid sample	n_3	1.316

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