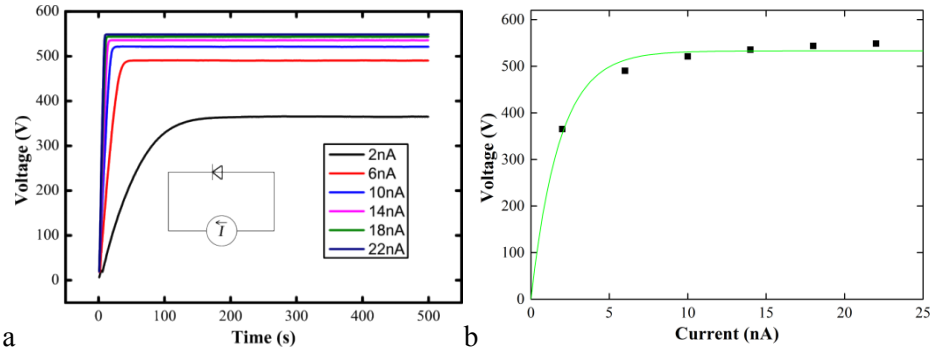
Electronic Supplementary Material (ESI) for Lab on a Chip.

Supplementary information

Measurement of reversely connected diode



a b

Figure 1. The I-V curve of a reversely connected diode (MULTICOMP - UF4001) was measured and is shown below. An accurate current source (Keithley 2410) was used to apply a constant DC current and measure the voltage difference in real time. a. Reversed voltage generated over the diode by a constant DC current as a function of time. It can be seen that a quite small DC current (4 nA) can produce about 500V between the terminals of the diode and this voltage will be almost independent of the current. As a result, we can use the inversly connected diode to produce a constant gate voltage allowing more stable energy conversion. b. The I-V curve after 500 seconds. At higher currents the voltage becomes saturated and independent of the applied current, so that the gate voltage will remain constant and won't overcharge the droplets. Green solid line indicates the expotional fitting of voltage on diodes as function of current through.

Equivalent circuit of self-excited system

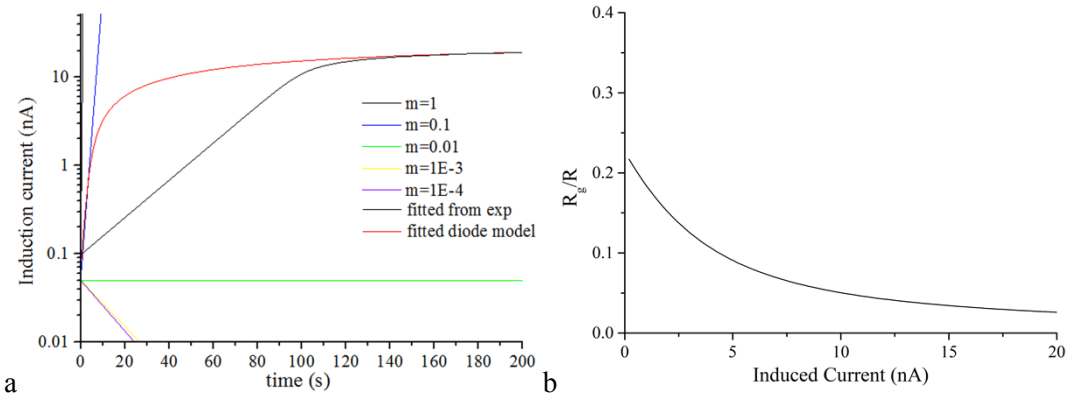


Figure 2. Comparision of induction currents in different models as time passes. By equation (3) and (4) in the paper, we could calculate how the induced current as a function of voltage division m= $R_g/(R_g+R_{Load})$. It can be seen clearly that the induction current increases quite fast when m > 0.01 (assuming nCind=0.1nA/V), represented as a positive feedback system. While m < 0.01, current decreases as a negative feedback system so that droplets will be non-charged. The decreasing rate of induction current in small gate resistance is determined by RC time in downstream circuit, thus further decrease of gate resistance won't change the current decreasing rate anymore. However, by using reversely connected diodes, the induction current increases quite fast at beginning and gradually reach to a saturated value, behaving similarly as our experiment (figure 4).

Image of a cone spray

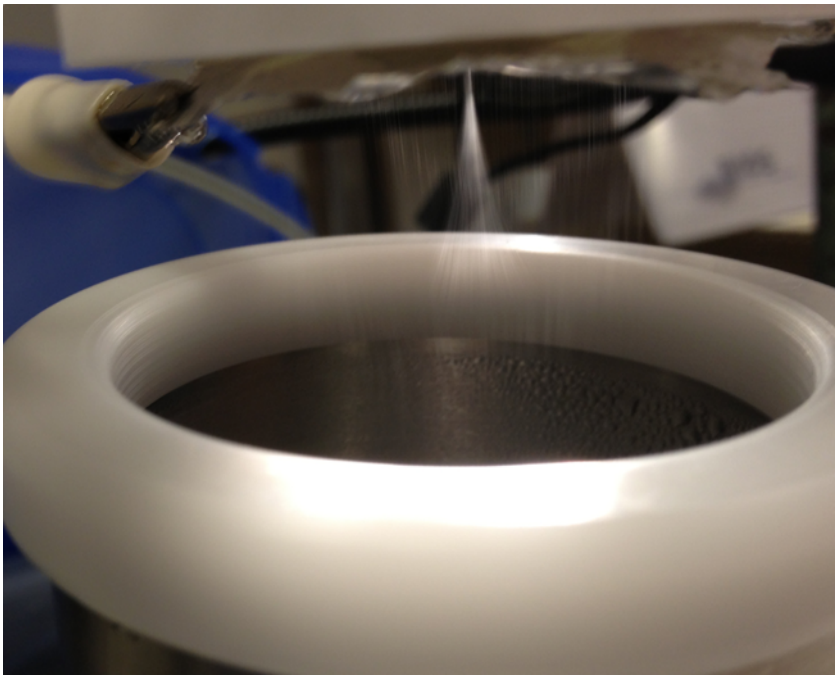


Figure 3. The spray cone of liquid jet in Kelvin's connection. As can be seen from experiments, when electrical circuit was connected, droplets are quietly highly charged. The charged droplets repel each other forming a spray cone. To prevent the electrical discharge between gate and target, we add Delrin cover on the targets. However, partial droplets landed on the covers inducing dissipation of electrical energy. A better design of device are preferably to be built.