English
Research Express@NCKU Volume 17 Issue 8 - March 18, 2011
[http://research.ncku.edu.tw/re/articles/e/20110318/1.html]

Advancement of enabling micro/nano-fluidics technology for biomedical applications

Gwo-Bin Lee
Department of Engineering Science, National Cheng Kung University, Tainan, Taiwan
gwobin@mail.ncku.edu.tw

NCKU Landmark Project《A001》

Biomedicine and optoelectronics are among the most potential research fields nowadays. In this landmark project, we have demonstrated several new fabrication techniques applications for the optically-induced dielectrophoresis (ODEP) platform, which combine the knowledge from these two fields. It will open up a new era for microfluidic applications. The cost of the biochips using this technology can be relatively low and no complicated lithography and metal patterning process are needed, implying that a disposable system can be feasible. It is envisioned that the developed system can provide a revolutionary platform for biomedical applications and may provide a user-friendly, flexible, and affordable tool for further biotechnology applications. The important achievement will be summarized as follows.

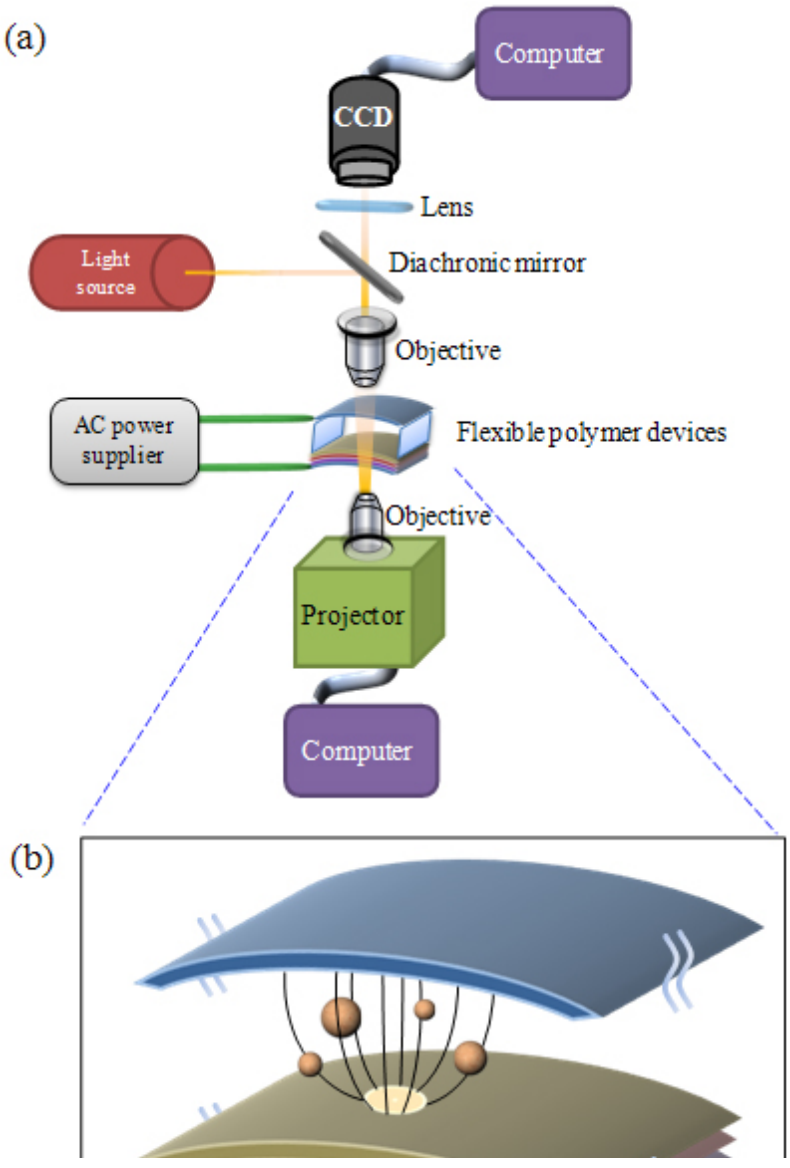
1.Rapid separation and manipulation of micro-particles using optical images on flexible polymer devices

The optically-induced dielectrophoresis (ODEP) platform fabricated on amorphous silicon substrates or thin-film polymer-based glass substrates has been reported as a promising technique for particle/cell manipulation. The complicated fabrication process of micro-electrodes for generating DEP forces can be simplified by using “virtual” electrodes formed by light illumination. However, amorphous silicon is usually fabricated by plasma-enhanced chemical vapor deposition (PECVD), which is usually expensive and high-temperature process. Alternatively, photoconductive polymers can be spin-coated on ITO glass substrates at a low temperature. It also opens up a possibility to extend its applications on a polymer-based flexible substrate. Therefore, this study reports a novel flexible polymer device coated with photoconductive polymers fabricated at a low-temperature for rapid separation of micro-particles with the incorporation of gravity effect. The fabrication process is compatible with the roll-to-roll process such that large-area, flexible polymer substrates can be adopted for this application if necessary.

Figure 1 illustrates the experimental setup and the operation principle of flexible polymer devices. The flexible polymer devices can manipulate micro-particles utilizing non-uniform distribution of an electric field caused by the injected light patterns to induce ODEP forces, thus providing a manipulation force onto the polystyrene beads (Fig. 1(a)). The flexible ODEP device is composed of a donor/acceptor bulk-heterojunction (BHJ) polymer on a flexible ITO-PEN (indium-tin-oxide coated with polyethylene naphthalate) substrate as the light-activated layer (Fig. 1(b)). Regioregular-poly(3-hexylthiophene) (P3HT) combined with [6,6]-phenyl-C61-butyric acid methyl ester (PCBM) were used as a light-activated material for ODEP since the efficient electron transfer of the photo-induced excitons at the donor/acceptor interface can be generated. Hence, non-uniform electric field distribution between the arch-shaped top and the bottom ITO-PEN substrates can be induced when injecting light, such that the separation of micro-particles can be realized by the gravity effect and injected light patterns. Fig. 2 shows the measured maximum drag velocity (v_d) and the calculated induced DEP force (F_{DEP}) on the flexible polymer devices and the solid ITO glass substrates at different applied voltages (V_{PP}). Note that the thickness of the

polymer layer on the ITO glass substrate can be increased from 497 nm to 763 nm by preparing the stirring solution at 40ºC, such that the maximum v_d and the F_{DEP} for polystyrene beads (Ø=20 μm) can be 445 μm/s and 83.9 pN at 60 V_{PP} and 100 KHz, respectively (Fig. 3). For flexible polymer devices, the maximum v_d and F_{DEP} are measured to be 183 μm/s and 34.6 pN, respectively, which is comparable with one from our previous work on the ITO glass. Fig. 3 also shows the maximum v_d and F_{DEP} on the polystyrene bead for BHJ active layers with different thickness. It is observed that the thicker the film, the higher the F_{DEP}. 150 μm/s and 28.33 pN for v_d and F_{DEP} can be generated when the thickness of the P3HT:PCBM film is 763 nm when operated at 30 V_{PP} and 100 KHz.

Figure 4 show a schematic illustration of the working principle for the separation of micro-beads. A light beam is firstly illuminated across the flexible devices to generate a negative DEP force (Fig. 4(b)), such that the micro-beads (Ø=20.0μm) can be collected between two virtual electrodes (peak region of the arch-shaped devices, Fig. 4 (c)) while the micro-beads (Ø=40.0μm) would be rapidly repelled to the other side (valley region of the arch-shaped devices, Fig. 4(d)) under the gravity effect. With this approach, beads with different sizes can be easily separated. Figure 5 shows a series of images indicating the beads can be separated successfully. In summary, we have reported, for the first time, the flexible polymer devices for rapid separation and manipulation of micro-particles utilizing the ODEP technique.



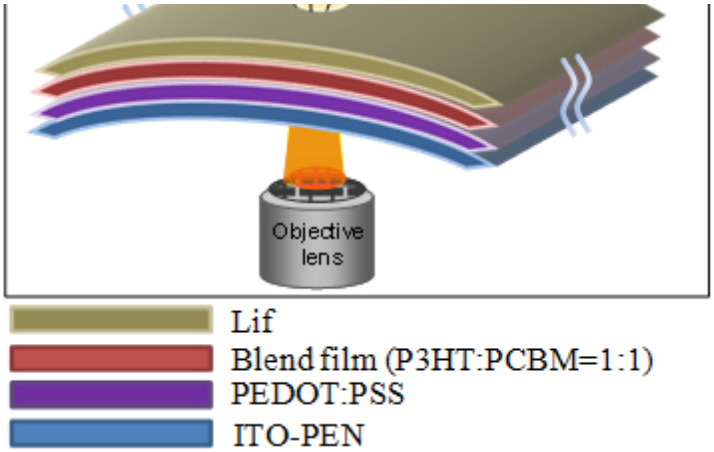


Figure 1: (a) Schematic illustration of the experimental setup. (b) The flexible polymer devices are composed of a sandwiched structure composed of a top flexible substrate (ITO-PEN), a liquid layer containing particles and a bottom flexible substrate coated with a PEDOT: PSS layer, an active layer of P3HT and PCBM and a LiF layer.

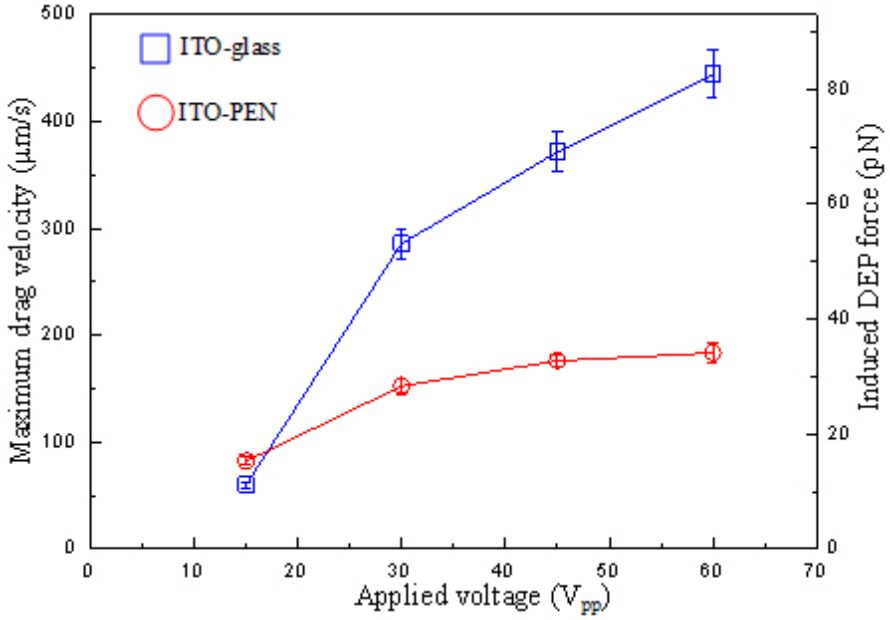


Figure 2: The measured maximum drag velocity (v_d) and the induced DEP force (F_{DEP}) at different applied voltages (V_{PP}) for ITO glass and ITO flexible device.(n=3)

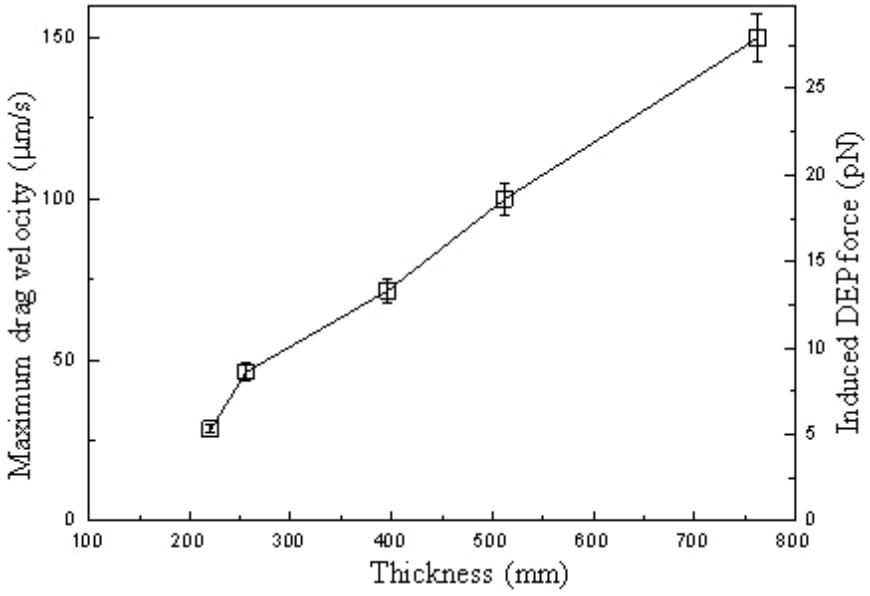


Figure 3: Tthe maximum v_d and F_{DEP} on the polystyrene bead (Ø=20 •m) for BHJ active layers with different thickness.(n=3)

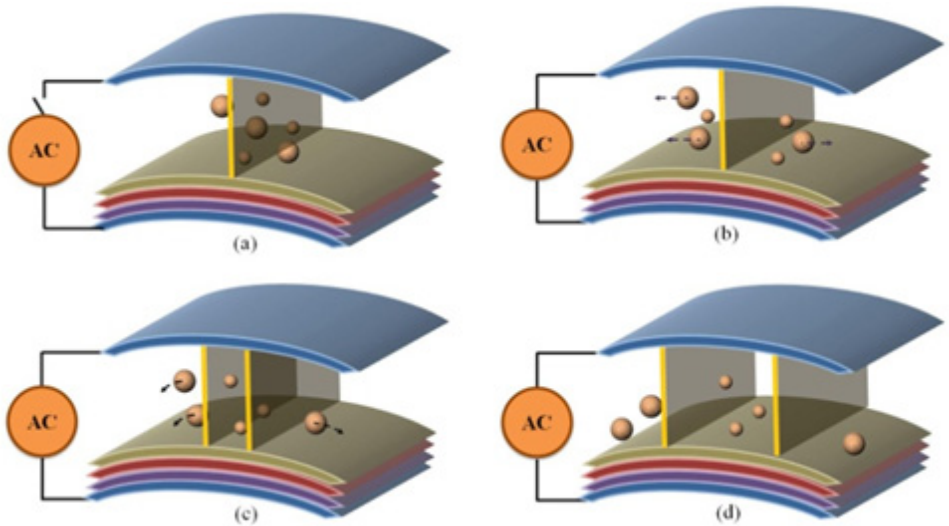


Figure 4: Schematic illustration of the working principle for the separation of micro-beads.

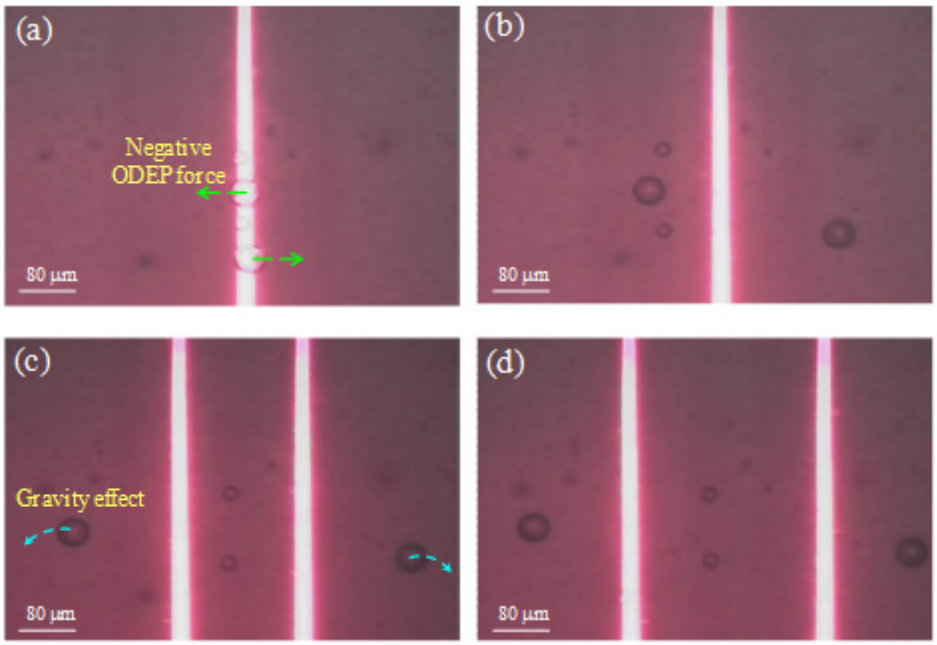


Figure 5: Images showing that the separation of micro-beads can be successfully achieved.

Copyright 2010 National Cheng Kung University