Introduction: The aim of this work is to develop a new method with the potential to revolutionise the process of assembling micron/nanoscale electronic components into circuits. This will be accomplished by developing a radically new assembly strategy based on a touch-less opto-electro-fluidic manipulation technique known as optoelectronic tweezers (OET). In this work, we demonstrated the use of OET to manipulate conductive silver-coated Poly(methyl methacrylate) (PMMA) microspheres (50 micron diameter) into different patterns. It is found that the microspheres can be moved at a maximum velocity of 3200 µm/s, corresponding to 4.18 nano-newton (10^-7 N) DEP force, and also be positioned with high accuracy due to this high DEP force.

Background

What are optoelectronic tweezers?
Optoelectronic tweezers (OET) is a technology using a light-patterned photoconductive electrode to provide real-time control over the positioning of electric fields, thus achieving particle trapping and manipulation [1].

The structure of an OET device
An OET device, shown in Fig.1 (a), typically consists of an upper and a lower glass slide coated with a transparent conductor (typically indium tin oxide, ITO) with the lower slide coated with an additional photoconductive layer (typically amorphous silicon (a-Si:H)).

How does an OET device work?
A light pattern is projected onto the device which creates non-uniform distribution of electric field around the area which has been illuminated. In this case, ‘virtual electrodes’ are generated, which can be used to corral polystyrene microbeads via dielectrophoresis (DEP), as shown in Fig.1 (b).

Aims

Moving Electronic Components
The main aim of this work is to assemble electronic components into circuits using OET, producing a step change in the size of the smallest components that can be assembled using the current surface mount technology. We expect to fabricate high-performance micron-sized (or even nano-sized) circuits using OET: A schematic and an electronic image of using OET to move a resistor are shown in Fig.2 (a) and (b).

Moving Metallic beads to Create Conductive Path
Another aim is to use OET device to manipulate and pattern lines of conductive microbeads to form metal conductive paths acting as electrical contacts for the circuit, essentially as a form of mask-less lithography. Experimental results will be shown in the following part.

Experimental results

- Scanning electron microscope (SEM) image of silver-coated PMMA microspheres is shown in Fig.3.
- Schematic experimental setup is shown in Fig.4 (a). The metallic microspheres were attracted to the illumination region due to positive DEP force, as shown in Fig.4 (b) and (c).

Conclusion: We have demonstrated the use of OET to manipulate conductive silver microspheres into different patterns. It is found that the microspheres can be exerted with strong DEP force (10^-7 N) and also be positioned with high accuracy. The aim of this work is to develop a new method to assemble micron/nanoscale electronic components into circuits.

References