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Micromachining of a Novel Electric Eel Inspired Microchannel for Bio-nano Particle Separation

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ABSTRACT

Microfluidic technology is becoming increasingly prevalent in modern day biomedical devices. They are found to be applicable in cell separation, focusing, isolation, differentiation, and categorization. In this study, we intend to separate nanoparticles from microparticles in a fluid using a microchannel of triangular cross section inspired by the Anguilliform motion of the electric eel. This is to mimic the separation of bio-nanoparticles in blood such as antibodies, proteins, and genetic material (DNA, RNA (etc.)), from the bio-microparticles such as red blood cells (RBCs), white blood cells (WBCs), Circulating Tumour Cells (CTCs) and Platelets. Y. Arcot et. al. fabricated serpentine microchannels for the separation of blood cells from plasma. They obtained 81% separation at 1:100 dilution. A. Amani et. al proposed a novel divergent serpentine Inertial microfluidic channel for the separation of circulating tumour cells from regular RBCs. The present study is focused on analyzing the separation efficiency via simulation using the COMSOL platform and fabrication of the novel electric eel inspired microchannel using femtosecond laser of varying spot diameter (from 150 μm to 40 μm) to facilitate the formation of triangular cross section microchannels. The microchannels are designed using the equation:

$$h_{eel}\,(x, t) = (0.0071 - 0.0179x + 0.0758x^2) * \sin\,(19.54t - 10.40x) \quad (1)$$

The material of choice for microchannel fabrication is Poly-methyl methacrylate (PMMA), as it a cost-effective and readily available biomaterial with suitable mechanical properties for micromachining. The PMMA sample was subject to both Femtosecond laser machining as well as Micro-milling in order to observe which of them offered the best surface finish as well as a convenient and controlled machining operation. The results clearly indicated that machining PMMA via micro-milling offers a better surface finish as compared to the femtosecond lasing of PMMA. The micro-milling parameters were further optimized to achieve a well-cut microchannel, free from uneven edges, uneven bases, or high amount of burrs (poorly cut channels).

The future works that need to be done include performing simulations using COMSOL, to find out whether we are able to obtain the hypothesized results. Flow Simulation of the electric eel-based microchannel using micro and nanoparticles along various cross sections such as Triangular cross section, trapezoidal, and rectangular to find the optimal cross section used for separation of bio-micro from the bio-nanoparticles. The electric eel-based channel will be compared with standard channels such as the inertial focusing channels as mentioned in the literature earlier, to check its separation efficiency.

Keywords: Electric eel, triangular cross-section, microchannel, femtosecond laser.

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