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Design of MEMS-based Microfludic Channel to Detect Cancer Cells in Blood

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ABSTRACT

Cancer refers to any of countless infections characterized by the development of abnormal cells that divide uncontrollably and can invade and destroy normal body tissue. Malignant growth frequently can spread all through your body. Cancer is the second driving reason for death on the planet. In this paper, we propose to found a H-cell to screen carcinogenic cells in a given sample of blood based on the principle of diffusion. This model incorporates the planning of a MEMS-based microfluidic channel to screen and recognize different cells depending on the size and various characteristics of the cells. Some of the methods which are implemented not efficient models for cancer cells detection in blood. The mass, displacement technique has been implemented in this investigation for cancer cell detection, with the help of this achieves the accuracy and better throughput. One cancer cell contains = 1.70371e-24 mass, such that with a weight of this formula, find out the total no of cells in the blood. This is the best method compared to existed methods. Using this count, the weight has been calculate early-stage cancer and treatment with a simple manner, CTCs in the blood is the un potential matter for health, H-cells have been measured with proposed weight and force technique such that in this investigation also calculate the healthy and cancer cells also. Finally, using this methodology achieves 93.58% accuracy, 0.00124 MSE. These are very good results compared to conventional methods.

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INTRODUCTION

Cancer is the subsequent driving reason for death, causing one of each four passing in North America (Jain, 2005). More than 90% of cancer deaths result from metastasis, in which some cancer cells escape from the primary tumour, circulating in the bloodstream before spreading to distant organs. As a result, circulating tumor cells (CTCs) in the peripheral blood have the potential to become a biomarker for early-stage cancer diagnosis, prognosis, and metastasis prevention/treatment (Fan *et al.*, 2017). So, early cancer detection is crucial for improved prognosis and cancer management due to the small tumor size and localization of the tumor at the primary site (Schiffman *et al.*, 2015). We show that H-cell measurements designed and operated according to the identified principles lead to a fast, efficient and cheap method for high-throughput diffusion analysis (Häusler *et al.*, 2012). Despite the fact that the most significant treatment is careful action of emptying the bowels or another bodily organ of the tumor, the way into a fruitful fix

is regularly a proficient conveyance of anticancer medications after the medical procedure. For successful cancer treatment, all areas of the tumour must be exposed to chemotherapy agents. If just the tumour's outer cells are killed, the tumor will eventually regrow (Nguyen and Hoang, 2017). Numerous new medications have been created to kill malignant growth; however, are inadequate when utilized in people for the absence of effective conveyance. Conveyance is nothing but the process of transporting someone or something from one place to another. Also, all medications have capable of being imagined symptoms, for example, danger to ordinary cells and the advancement of medication obstruction. Remaining tumour cells and re-development of tumours are normal spin-offs of the utilization of the vast majority of these medications. The medications most observable action of confining is their failure to arrive at a focused on zone without influencing solid tissues or cells. The two contemplations in powerful malignant growth treatment, from a building perspective, are medication transport and medication change or response at the tumor site. Different medications actuate biochemical responses in the body that has the capacity to cause death or serious harm or damage different organs of the body such as heart rate, temperature, respiratory rate, and blood pressure. It is said that "Prevention Is Better Than Cure." Since there is no proper cure for malignancy, it is preferable to prevent it at initial stages only. The extraction of cells of interest directly from whole human blood is in high demand. However, it is extremely challenging due to the excessive cell populations leading to non-Newtonian hemodynamics. Herein, a simple microfluidic approach is described to take advantage of the concentrated cells for direct isolation of larger particles spiked in whole blood, which could shift the current paradigm in cell separation from low volume fraction sample to concentrated suspension and from the Newtonian to non-Newtonian fluid (Goldacre and Sylvén, 1962; Zhou *et al.*, 2017; Armakolas *et al.*, 2010). So, a design has been developed to detect carcinogenic cells based on the principle of diffusion. Cancer cells, which are bigger than the normal cells, will go down based on the principle of diffusion. Other malignancy cell arranging strategies, which have been checked on elsewhere, including centrifugation, chromatography, fluorescence and magnetic-activated cell Sorting, are restricted in terms of purity and the amount of output and also they depend on the thought process of individuals designing them (Danova *et al.*, 2011; Kim and Jung, 2010). Especially, MEMS components are being widely used in the medical applications as they are portable, miniature in size and have a uniqueness in their application, fabrication and functionality (Yu *et al.*, 2011; Zieglschmid *et al.*, 2005). In this paper, a MEMS-based H parameter cell is proposed to detect carcinogenic cells from a given sample of blood. This concept is preferred as the model requires samples in the range of microliters, which is one of the major advantages of this model (Shameem *et al.*, 2019b,a). It also consumes less power and the fundamental noise floor is also less (Yarraguntla *et al.*, 2018; Prasad and Syed, 2016). This cell is designed based on the various parameters of blood (Prasad *et al.*, 2016). Here, the inlet is blood and the cells in the blood, which are heavier and larger than the normal cells, settle at the bottom (Prasad *et al.*, 2017; Yarraguntla *et al.*, 2018). This is how cancer cells are separated from normal cells using the principle of diffusion (Siddaiah *et al.*, 2018; Sateesh *et al.*, 2018).

METHODOLOGY

In this paper, three important methodologies play a major role in cell design. The analysis and detection of the parameters that occurred due to different changes in the profile of blood are influenced by these properties of the considered input (Shameem and Babu, 2018; Shameem *et al.*, 2018; Prasad *et al.*, 2018a).

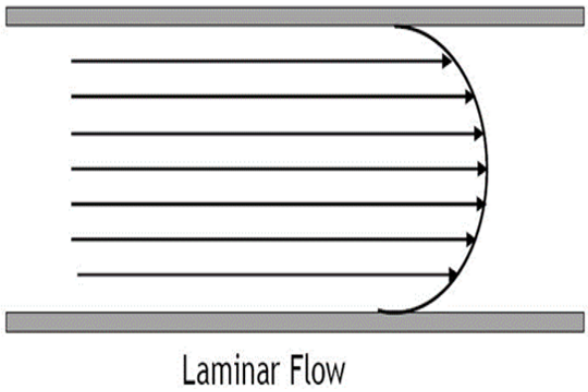

Figure 1: Laminar Flow of a Fluid

Laminar flow

In fluid dynamics, laminar flow is characterized by fluid particles following smooth paths in layers, with each layer moving smoothly past the adjacent layers with little or no mixing (Häusler *et al.*, 2012). Laminar flow is a system described by high energy diffusion and low force convection shown in Figure 1.

Average Velocity Of Laminar Flow

The velocity profile u(r) of the laminar flow of the fluid inside the pipe is given by applying the boundary conditions $\partial u/\partial r = 0 \; at \; r = 0$at r = 0 (because of symmetry about the centerline) and u = 0 at r = R

Table 1: Parameter Analysis

Mass(Kg)	Force(N/m^2)	Displacement(m)
1.70371e-24	-1.7372e-25	-3.5961e-51
1.70371e-23	-1.7372e-24	-3.5961e-50
3.40742e-23	-3.4745e-24	-7.1922e-50
8.51856e-23	-8.6864e-24	-1.7980e-49
1.70371e-22	-1.7372e-23	-3.5961e-49

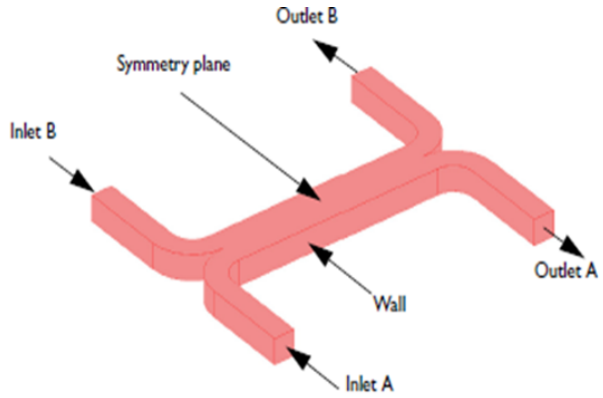

Figure 2: Model domain boundaries

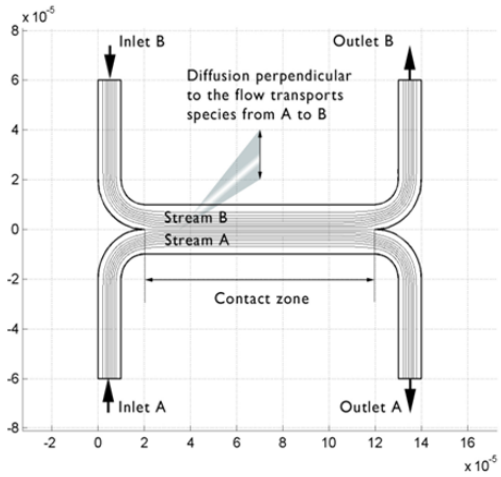

Figure 3: Diagram of the H-microcell (Dimensions in meters)

(the no-slip condition at the pipe surface). We get,

$u(r) = \frac{-R^2}{4\mu}(\frac{dp}{dx})(1 - \frac{r^2}{R^2})$..... (1)

From the above equation, we tell that the velocity profile is maximum at centreline and minimum at the boundaries (Nguyen and Hoang, 2017).

Microfluidics,

Microfluidics deals with the direct, accurate control and control of fluids that are geometrically obliged to a little, commonly sub-millimeter scale. Micro has the following features,

1. Small volumes

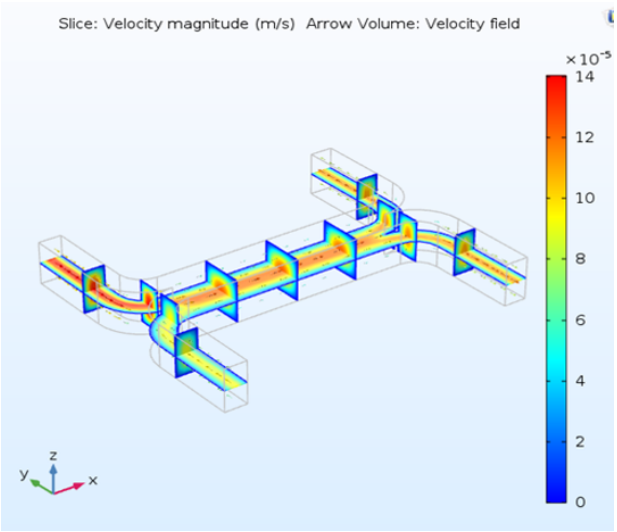

Figure 4: Velocity profile in a pipe

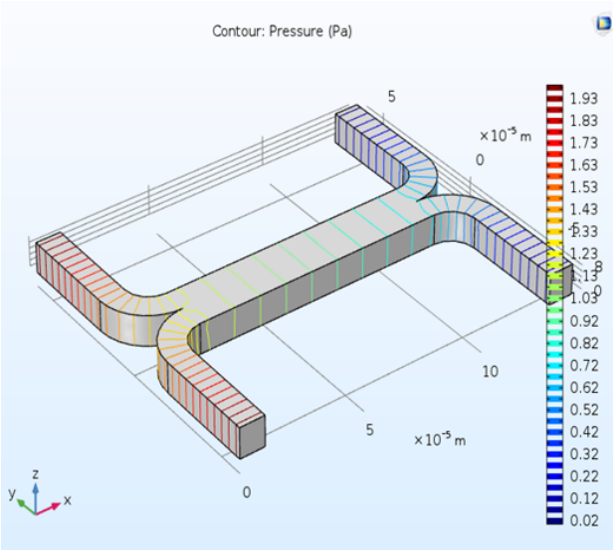

Figure 5: Pressure profile in a pipe

2. Size is less

3. Energy consumed by these devices is also very less

4. Micro-domain effects are present

Design

COMSOL Multiphysics is a cross-stage limited component investigation, solver and Multiphysics repro-

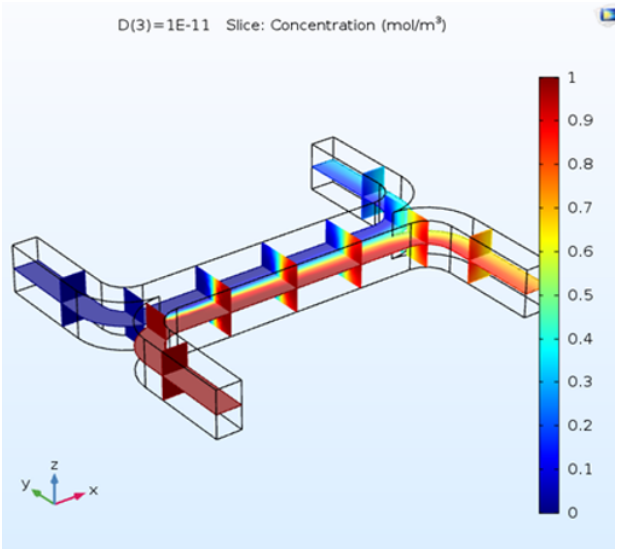

Figure 6: Concentration distribution for a species with diffusivity 1·10−11m2/s

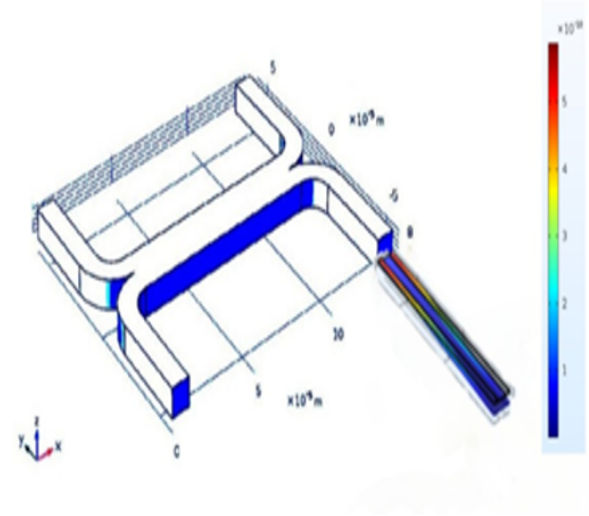

Figure 7: Displacement variation at force = -1.7372e-25N/m²

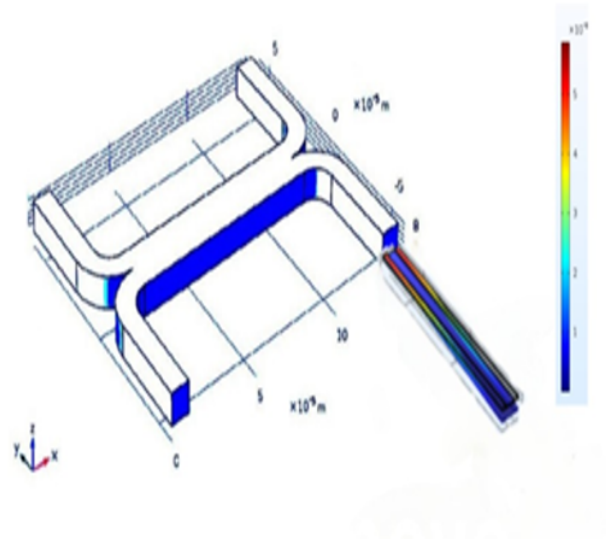

Figure 8: Displacement variation at force = -1.7372e-24N/m²

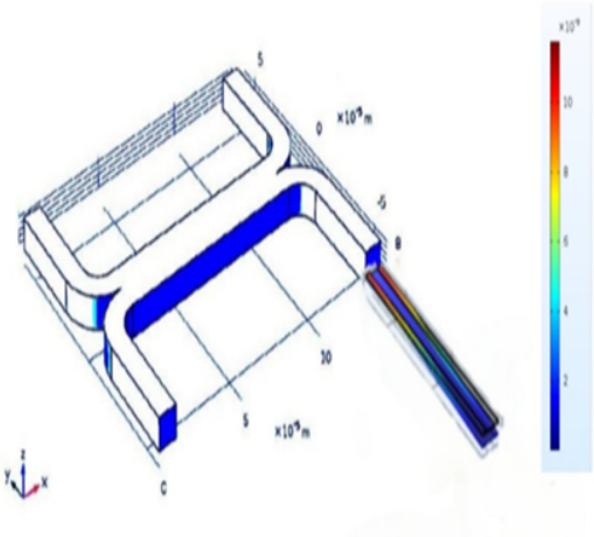

Figure 9: Displacement variation at force = -3.4745e-24N/m²

duction programming. It permits ordinary material science-based UIs and coupled frameworks of incomplete differential conditions (PDEs). COMSOL gives an IDE and bound together work process for electrical, mechanical, liquid, acoustics and compound applications (Prasad *et al.*, 2018b).

This software has a significant role when it is required to know about the physics that is affecting the system. Simulation of the present channel design is done in COMSOL and multi-physics such as Laminar flow and transport of diluted species is used.

H-parameter cell has 2 inlets and 2 outlets and the symmetric plane where the fluid flows, as shown in the Figure 2.

This models an H-microcell for separation through diffusion. In Figure 2, it is shown how the cell puts two distinctive laminar streams in contact for a controlled timeframe. The contact surface is very much characterized, and by controlling the stream rate, it is conceivable to control the measure of species moved from one stream to the next through dissemination. The model uses the Laminar Flow and Transport of Diluted Species interfaces to completely catch the partition inside the cell (Han *et al.*, 2013).

The recreations include tackling the liquid stream in the H-cell. As per the details, the stream rate at the inlet is generally 0.1 mm/s. This infers a low Reynolds number, well inside the district of a laminar stream:

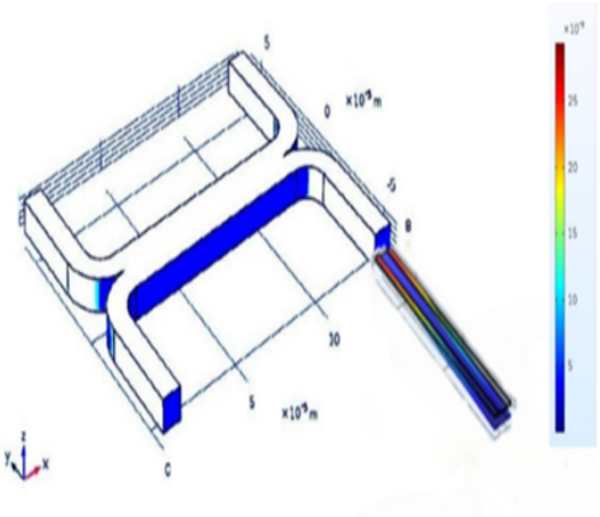

Figure 10: Displacement variation at force = -8.6864e-24N/m^2

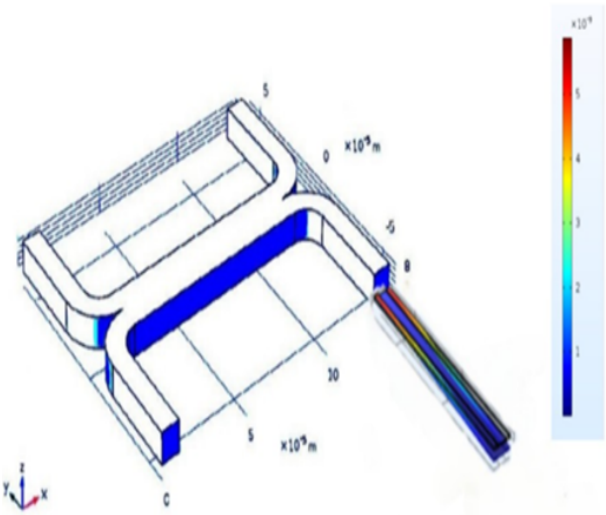

Figure 11: Displacement variation at force = -1.7372e-23N/m^2

It is given that the Reynolds number of 0.002 for a blood arrangement and the channel measurements given in Figure 3. This value is run of the mill for miniaturized scale channels. Also, this demonstrates it is anything but difficult to get a numerical arrangement of the full momentum offset and progression conditions with a sensible number of components.

SIMULATION AND RESULTS

The main design parameter that is being considered while designing the cell is the concentration of the fluid shown in Figure 4 & Figure 5.

Average velocity and pressure simulations of laminar flow are done using COMSOL. From the above simulation figure, it is observed that the velocity of flow is maximum at the centre of the pipe compared to the boundaries and the pressure of flow is maximum at the inlets. Considering these results, the properties of blood are placed at the inlet and in the centre of the pipe is considered as the channel. They are shown in Figures 6, 7 and 8.

The structure of the H-microcell is designed in 3D.

This takes place by following the principle of diffusion. Since the diffusion principle separates the high concentration and low concentration particles, here, the separation is visible.

Figures 9, 10 and 11 shows that the species with high concentration are coming out through outlet B; this is the best method for finding blood cancer cells shown in the Table 1.

CONCLUSIONS

From the above values, by observing the force and displacement values, we can conclude the number of cancer cells present, i.e., by using Newton's second law F=ma, considering m=mass of cancer cells and a=acceleration due to gravity. Therefore, a mass proportional to the obtained force is determined. Considering the mass of 1 cancer cell = 1.70371e-24, we can find a number of cancer cells present. Hence, we can see that as the force increases, the displacement also increases. This shows that the heavy cancer cells are diffused and falling on to the cantilever and causing displacement.

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