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Elimination of cancer cells by resistive heating method using Comsol multi physics

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ABSTRACT

Localized heating is poised to become an integral part of microfluidic devices in various life-science applications. The elimination of cancer cells are done using resistive heating method. Many methods are adopted for cancer elimination. But this method will be more useful for elimination the cancer cells. By using mems, COMSOL Multiphysics technique by resistive heating method the cancer cells will be get eliminated. This is catalyzed by the scale of economics, the advantageous fluidic behavior at small volumes, and the ever increasing need for rapid and high throughput assays for pharmaceutical industry and other combinatorial based studies. For precision confined heating, thin film resistive heaters have proven to be superior to the conventionally used Peltier elements, which are often a hindrance to miniaturization and functionality integration for thermally sensitive application. The resistivity of certain metals varies predictably with temperature, making them suitable for use as temperature sensors. If a thin film could be designed so that it preserves a uniform temperature distribution during heating, its total resistance would accurately reflect its temperature, allowing it to simultaneously act as both a temperature sensor and a heater.

Introduction

Conventional molecular biology techniques can provide much insight into the nature of many diseases, both for diagnosis and for subsequent monitoring of progress. The adapatation of these conventional techniques onto microchip platforms would render them substantially faster, less labor intensive, and inexpensive both in terms of operating cost and of low volume reagent usage, allowing their introduction into the clinical setting as powerful analytical tools for disease detection and monitoring and elimination. Many molecular biology techniques require the use of precise and uniform heating systems to catalyze successful and accurate biochemical reactions (Hoang and Govind 2005). The biochemical reactions take place in a chamber coupled closely to a heater. The thin film resistive metal heater has emerged as the most suitable choice for such localized heating applications within microsystems. One of the main advantages of thin film heaters over other types of heaters, such as Peltier elements, is that they can operate/respond extremely rapidly and have a relatively low power consumption.

Targeting the cancer cells

A optimize clinically relevant parameters is to maximize thermal energy deposition at the tumor site and minimize thermal diffusion and global energy deposition. The parameters include nanoparticle concentration, molecular bond energies, external magnetic field strength and frequency. The models are also being used to investigate aspects of particle delivery, migration, and agglomeration, nanoparticletargeting molecule bond breaking, effects of perfusion on energy dissipation and diffusion, and the non-linear nature of thermally induced cell-death mechanisms (Carl Kumaradas and Robert 2005). Targeting of cancer cell is shown in Fig. 1. This will break the bond between the cancer cells.

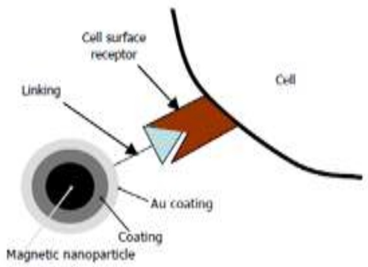

Figure.1 Targeting cancer cells

The methods for elimination of cancer cells

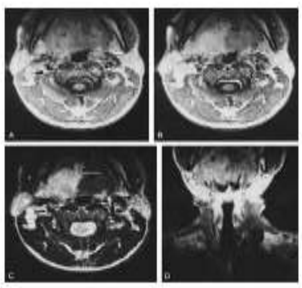

Figure.2 presence of cancer cells

Although the large-scale analysis of the human genome has provided a wealth of information for the genetic analysis of cancer and other diseases, (Backhouse 2003) most of these advances are unavailable in the clinic due to their expense and complexity. By using resistive it will not be complex and elimination of cancer will be possible.Presence of cancer cells is shown in Fig.2.

Resistive Heating:

The material heats up when an electric current passes through it due to electric resistance. This is called resistive

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heating or Joule heating. There is also a coupling working in the opposite direction: the material's electric resistance varies with the temperature, increasing as the material heats up.

Insulation of copper

Imagine a copper plate measuring 1 m × 1 m that also contains a small hole. The plate's thickness has no effect on the model. Suppose that you subject the plate to an electric potential difference across two opposite sides (all other sides are insulated). The potential difference induces a current that heats.

Copper is selected here as the heater material since it has a good thermal response at relatively low voltages and a resistivity that exhibits a highly linear dependence on temperature. This latter property also makes copper a suitable candidate for use in temperature sensors.

However, to have its total resistance accurately reflect its temperature, the temperature distribution in the metal film must be uniform, which is usually not the case when it undergoes significant resistive heating (Hoang and Govind 2005). As a result, many research groups implement a second, smaller and passive metal film in their chips to function as a sensor. Nonetheless, if the thin film heater could be designed to have a uniform temperature distribution, it would be able to act simultaneously as both a heater and a sensor.

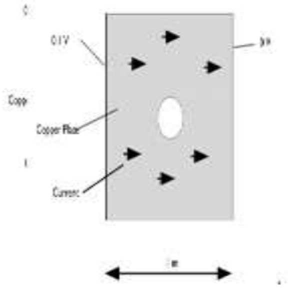

Figure.3 The model geometry and electric boundary conditions

The electric boundary conditions are mentioned. For the thermal boundary conditions, an air stream at 300 K (27 °C) cools the plate except on the thermally insulated upper and lower edges:

In Joule heating, the temperature increases due to the resistive heating from the electric current. The electric potential V is the solution variable in the Conductive Media DC application mode is shown in Fig.3. The generated resistive heat Q is proportional to the square of the magnitude of the electric current density J. Current density, in turn, is proportional to the electric field, which equals the negative of the gradient of the potential V.

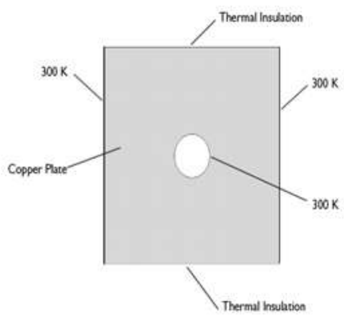

Figure.4 The model geometry and the thermal boundary conditions

The coefficient of proportionality is the electric resistivity $\rho = 1/\sigma$, which is also the reciprocal of the temperature-dependent electric conductivity $\sigma = \sigma(T)$. Combining these facts gives the fully coupled relation.

This resistive heating source term is directly available as the variable Q_dc (Q_emdc if you use the AC/DC Module) and is predefined as the source term in the heat transfer application mode when using the Joule Heating predefined multiphysics coupling. Quantities other than σ also vary with temperature. For exam ple, the thermal conductivity is temperature dependent, and a refined model would take this into account. Over a range of temperatures the electric conductivity σ is a function of temperature T according to

$$\sigma = \frac{\sigma_0}{1 + \alpha(T - T_0)}$$

where σ0 is the conductivity at the reference temperature T0. α is the temperature coefficient of resistivity, which describes how the resistivity varies with temperature. A typical value for copper is 0.0039 per kelvin. Thermal insulation will minimize the thermal diffusion (Robert H.Kraus 2005). In the Conductive Media DC application mode you can specify the electric conductivity for Joule heating in terms of this equation. The predefined multiphysics coupling sets up this specification of sigma with the variable for temperature in the T edit field and default values suitable for copper. The only thing you have to add is the reference temperature, T0.

Heat Transfer

The material properties for heat transfer are:

The unit for heat capacity in this model is J/(kg•K), the SI unit. This coefficient has the SI unit W/(m•K) and represents the material's ability to conduct heat per unit time. The predefined setting in the Heat source is Q_dc (or Q_emdc). This is a predefined variable for the resistive heating from the Conductive Media DC application.

Mesh generation targeting the cancer cell

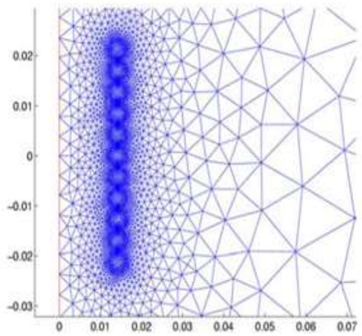

Figure.5 Mesh generation

The models that have been developed were first used to optimize the design of a small bench-top device for heating samples. Part of the mesh from a simulation of the magnetic fields. The cancer cells are targeted by the magnetic particles.

Heating Process

The heating prototype on the other hand could be built using readily available components. The heating in the design shows is low due to the fact that target was assumed to contain a low concentration of magnetic particles in water. A low concentration avoids the problem of particles attracting each other and agglomerating. The concentration of particles in tissue on the other hand can be much higher, resulting in heating that we expect will be at least above 20 °C / min. The results shown in this paper are from models that will be extended. The particle dynamics modeling was done on the side and analytic expressions for the heating rate as a function of magnetic field strength and frequency were derived and used.The heat transfer and its value is shown in Table 1. Future models will directly couple the simulations to the particle dynamics simulations. This is representative of a medium in which its entire infinite volume is heated at the same rate. COMSOL based finite element models have been developed to account for heat conduction as well as heat transfer due to blood flow. This model will be coupled to the particle dynamics model, as illustrated. Temperature dose relationships have been developed to relate the amount of tumour or tissue damage to the time-temperature history of heating (Erickon and Sinton 2003). This relationship described a time-temperature profile by a single iso-effect unit called "equivalent minutes are above 20°C."

Results of resistive heating

Initial Design

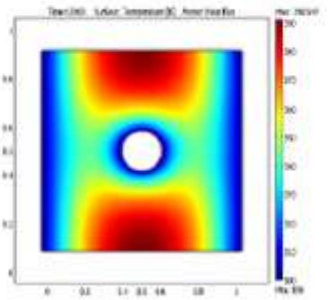

Figure.6 Initial design

Optimized heating

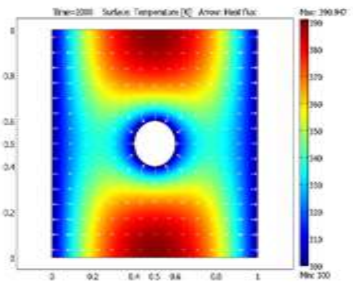

Figure 7 Optimized design

The heat transfer in this model is a transient process, so the model uses a time-dependent solver for a transient analysis. The graph shown above is regarding various temperature shown Fig.8 and resistive heating methods shown Fig.9. The optimized design in shown in Fig 7 shows the resistive heating method which describes the elimination of cancer cells. According to body temperature heat is given to patient and cancer cells are destroyed

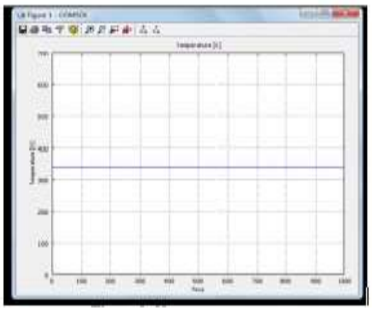

Figure 8 Various temperatures

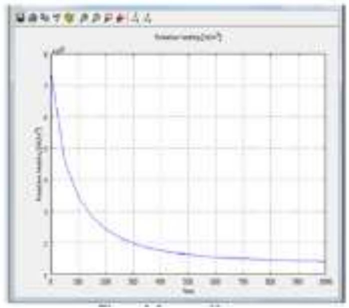

Figure.9 Resistive Heating

Conclusion

The design that was developed optimizes the temperature uniformity in a localized chamber within the chip as well as on the metal film's surface, as desired. Being able to provide uniform heating of the chamber and to utilize the element simultaneously as both a heater and a sensor was the intent. The variations in the temperature determines the heat that is sufficient to destroy tumor. Resistive heating according to the body condition it provides the heat from 300k to 370k to destroy the tumor cells.

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Table 1 Heat Transfer

Property	Value
P	9000
C_p	400
K (isotropic)	410
Q	Q_dc