Simulation Characteristics of Thin Film of the Touch Screen

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Abstract

Thin films science and technology plays an important role in the high-tech industries. Thin film technology has been developed primarily for the need of the integrated circuit industry. The demand for development of smaller and smaller devices with higher speed especially in new generation of integrated circuits requires advanced materials and new processing techniques suitable for future giga scale integration (GSI) technology.one of the most significant application of thin film is the touch screen, Thus, knowledge and determination of the nature, functions and new properties of thin films can be used for the development of new technologies for future applications. This research presents the principle of the thin-layer approximation in direct current conduction problems.

The approximation presented in this research is not limited to direct current problems: it can also use it for modeling of diffusion, heat conduction, flow through porous media using Darcy's law, and other types of physics that the divergence of a gradient flux describes. By applied the model it was determined , the total current density through the thin film, 5 slice for the current density across the thin film ,the variation of electric potential(V) with respect to current density through the thin film and the behavior of electric field through the region of thin film.

Keywords: Thin film characteristics, Thin film applications

1. Introduction

1.1Background

A touch screen is an electronic visual display that can detect the presence and location of a touch within the display area and represent one of the more significant applications of thin film. The term generally refers to touching the display of the device with a finger or hand. Touch screens can also sense other passive objects, such as a stylus. In other words, a touchscreen is any monitor, based either on LCD (Liquid Crystal Display) or CRT (Cathode Ray Tube) technology that accepts direct onscreen input. The ability for direct onscreen input is facilitated by an external (light pen) or an internal device (touch overlay and controller) that relays the X, Y coordinates to the computer.

The touchscreen has two main attributes. First, it enables one to interact directly with what is displayed, rather than indirectly with a cursor controlled by a mouse or touchpad. Secondly, it lets one do so without requiring any intermediate device that would need to be held in the hand [1].

The recent innovation of touch screen technology in mainstream applications has received acclaimed success in easing user in- tractions with data. The widely popular implementations of touch screens on personal handheld and mobile smartphones have redefined consumer expectations. The control of onscreen tasks is naturally intuitive and removes the traditional mouse and keyboard as limited input methods. In the industry of electronic devices, a successfully integrated touch screen can gain control of a dominant market share. The Apple iPhone, which was first launched in January 2007, had reintroduced the general public to the touch screen interface, which incorporated seamless application inputs and multi-touch control. While the concept of touch screen is not revolutionary, the responsiveness and versatility of on- screen control available in existing mobile units far exceed the performance of previous productions. The enhancements are primarily attributed to the technological advances of manufacturing processes, engineering design considerations, and user interaction with software interfaces [2].

The enhancements on modern manufacturing processes and engineering designs have facilitated the emergence of touch screens. A prevalent usage of touch screen technologies exist in conference rooms, educational classrooms, transportation schedules, financial institutions, simulation control rooms, staging, retail signage, and indoor venues. In 2013, the demand for public displays of touch modules and signage is expected to reach a forecast of 5.4 million units sold and a market segment worth $2.9 billion [2,3] according to an industry study completed in 2009.

1.2 The more related studies:

In 1963, Ivan Sutherland demonstrated the Sketchpad, the first interactive graphical user interface using a light pen to manipulate drawings comprised with physical knobs،push-buttons, and toggle switches [3]. Then in 1967, Douglas Engelbart introduced the two keyboards (alphabets and functional key cluster) and mouse [4]. Apple Macintosh popularized the use of special purpose keys with on screen graphical user interface widgets that have become widely accepted on desktop computers since the early 1980s. Recently, Apple has again revolutionized the multi-touch input screens on their iPhone and iPad product lines. The advantage of increasing the amount of information available over flat panel touch displays through user interface has been adapted predominantly in the auto- motive, retail cash register, mobile device, and the aerospace industries [5]. The use of touch screens prevail on handheld computing devices such as mobile phones, personal dig- ital assistant (PDA), digital cameras, and music players, where display space is restrictive [6].

1.3 The work of thin film touch screen

A touch screen is comprised of a touch panel, a controller and a software driver. The clear touch panel is a touch sensitive surface that is positioned directly in front of the viewable area on a display screen with a graphical user interface[7,8]. Touch events are registered and signals are sent to the controller to process the data to the computer system. The software driver then translates the received touch input events into the corresponding computer events. The main commercial implementation of touch screen technology are resistive, surface acoustic wave (SAW), infrared, optical imaging, and capacitive. All of the existing current implementation of touch screen technologies require at least one sensor and one receiver pair to send horizontal and vertical coordinates to a processor controller for localization of the signal. The design implementation requires that every resolution line is a unique input sensor on the screen and no signal reduction is attempted see figure (1) [9].

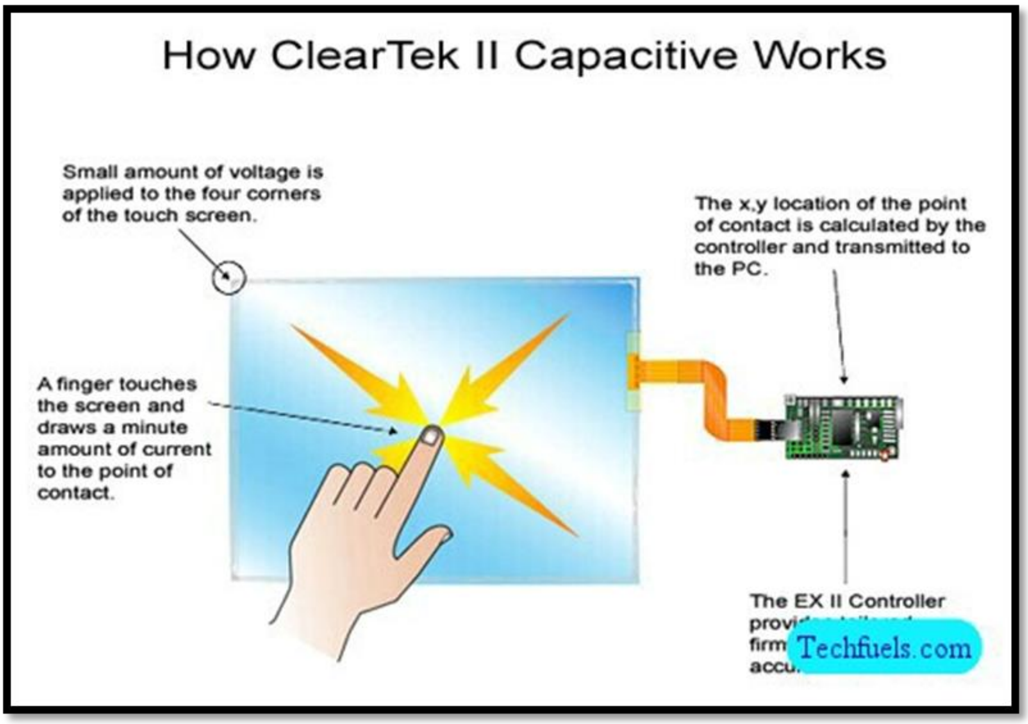


Fig.(1) principle of working of thin film touch screen

2. Theoretical principles

2.1 Theoretical background of thin film touch screen

When modeling transport by diffusion or conduction in thin layers, large differences in dimensions of the different subdomains are common. If the model has a sandwich structure, you can replace the thinnest layers with a thin-layer approximation, provided that the difference in thickness is large.

2.2Model Definition

This research presents the principle of the thin-layer approximation in direct current conduction problems. A comparison of a structure with three subdomains to a simplified model that replaces the domain in the middle with a thin-layer approximation shows the

Benefit of this approach (see fig 2).

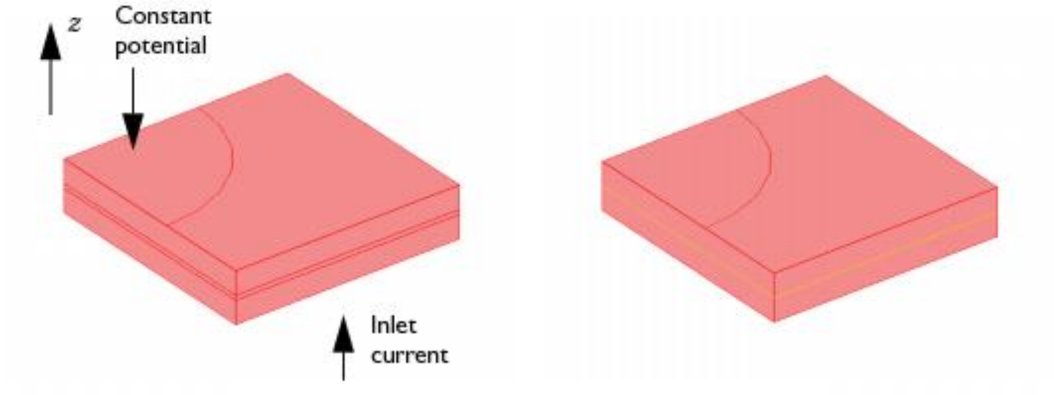


Figure (2) Exact domain description (left) and approximation (right). The current flows from the base plate to the circular plate on the upper surface of the device.

Equation 1 below describes the current balance in all three subdomains in the real sandwich structure:

$$\nabla \cdot (-\sigma \nabla V) = 0 \qquad \text{.......(1)}$$

In this equation, σ represents the conductivity and V the electric potential. In this case, there is a substantial difference in conductivity between the thin and thicker layers of the structure. The boundary conditions include a current inlet in the base plate of the device and a constant potential at the upper circular boundary (see Figure 2). All other boundaries are insulated.

The simplified model is based on the assumption that the components of the current density vector in the x and y directions are small and that the dominating transport through the thin structure is obtained in the z direction. For the middle layer, this implies that you can approximate Equation 1 by the one-dimensional equation

$$-\sigma \frac{d^2 V}{dz^2} = 0 \qquad \text{....................(2)}$$

It is possible to solve this equation analytically if the potential is given at the lower and upper surfaces of the middle layer:

$$V_{\delta = 0} = V_1$$

$$V_{\delta = \delta_1} = V_2$$

You can integrate Equation2 analytically to give:

$$V = az + b$$

Where a and b are integration constants. If you arbitrarily place z = 0 at the lower boundary of the middle layer, you get the constants a and b from the boundary conditions:

$$V_1 = b$$

$$V_2 = a\delta + b$$

This gives:

$$b = V_1$$

$$a = \frac{V_2 - V_1}{\delta}$$

The resulting equation for the potential is thus

$$V = \left(\frac{V_2 - V_1}{\delta}\right)z + V_1 \qquad \text{.........(3)}$$

The current density is defined as

$$J_z = -\sigma\frac{dV}{dz} \qquad \text{..................(4)}$$

Combining Equation 3 and Equation 4 gives

$$J_z = -\sigma\left(\frac{V_2 - V_1}{\delta}\right) \qquad \text{..........(5)}$$

In the thin-film approximation the potential is discontinuous at the film boundary. Using an assembly it is possible to model such a potential. The Conductive Media DC application mode has a contact resistance boundary condition available at pairs, which uses the thin-film approximation.

It is also possible to derive the expression for the current density in Equation 4 by approximating the gradient using the potential difference over the thin layer. This example includes the previous tedious derivation to show that this is exactly what you obtain from the solution of Equation 2.

The approximation presented in this research is not limited to direct current problems: it can also use it for modeling of diffusion, heat conduction, flow through porous media using Darcy’s law, and other types of physics that the divergence of a gradient flux describes.

In general, the application of this simplification is appropriate in cases where the differences in thickness are so large that the mesh generator cannot even mesh the domain. In some cases, the mesh generator might be able to mesh the domain but then creates a very large number of elements.

3. Modeling of thin film resistance

To build the model in the software of COMSOL multiphysics, select 3D from the model navigator window then conductive media DC which is represent electrostatic of conducting materials select from COMSOL multiphysics/ Electromagnetics. The following steps are procedure have been used to build the model

3.1 Construction the model

From the command bar select Draw/ Block and during this window should be enter all dimensions of the model as mentioned in the table. 1. For facilities make 2D planes in the 3D model by select Work plane setting from the command Draw.

Table. 1: Dimensions of the model

Name	Style	Length (*X, Y, Z*)	Axis base point (*X, Y, Z*)
BLK1	Solid	1, 1, 0.1	0, 0, 0
BLK2	Solid	1, 1, 0.1	0, 0, 0.1

The circle draw from the command Draw in the tool bar then select Specify Objects Circle at the center base with 0.6 radius and Axis base point x= 0, y =1. In this context, from Draw select specify objects to draw square at the corner with 1 width and set Cartesians x and y equal to zero. In the Draw command select create composite object and enter SQ1*C1, then select Draw/Embed CO1. To move the circle and quarter to the top of the model, select Draw/Modify/Move and enter Cartesians x and y equal to zero and z equal to 0.2. Select EMB1 and BLK2 then using Draw/Coerce to/Solid and Draw/Create pairs of BLK1 and CO1.

3.2 Subdomain settings

The main properties of the model should be enter in the subdomain edit window which it activate from the tool bar and select Physics then select subdomain 1 and 2. All information of the model mentioned in the table. 2.

Table. 2: Subdomain settings

Name	Expression	Description
σ	1	Electrical conductivity

3.3 Boundary settings

The initial conditions of the model can be entering from the command bar and select Physics/ Boundary settings. Table. 3 involve all values of the initial condition. In the Boundary settings / pairs tab select contact resistance and enter the values given during table. 4.

Table. 3: Boundary settings

Boundary	Initial Condition	Expression
1, 2, 4-10, 12, 13	Electrical insulation	-
3	Inward current flow	0.3
11	Ground	-

Table. 3: Boundary settings, Pairs

Name	Value	Description
σ	0.01	Electrical conductivity
d	0.02	Thickness in meters

4. Meshing

Select initialize mesh from the command Mesh in the toolbar. The thin film will divided to numbers of elements to solved numerically by using finite element method which is accurate numerical technique to solve thin film problems

5. Solving the model

Select Solve problem from the command bar select Solve.

6. Plotting

To display the solution of the model, from the tool bar, select Postprocessing/ Plot Parameters/ General. From the boundary tab select Conductive media Dc/ Electrical potential. To display voltage during the thin layer resistance, select Postprocessing/ Cross section plot parameters/ General, then select tab of Line Extrusion and select electrical potential in the data of y-axis, while in the X- axis dada select z in the expression. For the cross section plot, should be enter the data mentioned in the table. 5.

Table. 5: Data of Cross section plot

Name	Value
X_0	0.5
Y_0	0.5
Z_0	0
X_1	0.5
Y_1	0.5
Z_1	0.2

7.Results and discussion

The model has been constructed of thin film yield contour of total current density as declared in the figure. 3. In this contour the blue color referred into two thin layers of thin film and the value of it is extremely closed to $4.3*10^{-4}$. The arc appear on surface of the thin film layers display high value of total current density focused in middle with red color. The graded color from the middle of the arc to edges of the model implies to the dissipation of the total current density around sides of the model. In this context, figure. 4 clearly display slices of total current density and during this figure the high value of the current density disappears during transition from the surface of model toward the substrate. Figure. 7 shown total current density versus electrical potential and the behavior of this curve is linear. At the electrical potential extremely equal to 0.275 V the value of total current density closed to 1.575 A/m^2, during this, the value explosively falls in to 1.4 A/m^2 and from this point the curve decrease as the electrical potential increased. The minimum value of the total current density reached 0.425 A/m^2 at the 0.97 V electrical potential. The electrical potential shown in the figure. 6, display the first layer of thin film closed to substrate exposed to high value of electrical potential, while the upper layer of thin film emerged two distinct regions at the corners of the model.

The contour of electrical field shown during figure. 7, reveal high divergence of the data between the minimum and maximum values and the difference reach in to 5.596. These values assist to develop resistive heating as described obviously in the slices of resistive heating shown during figure. 8 and the maximum value of resistive heating is 24.484 W/m^3. The relationship between the resistive heating and the electrical potential display in the figure. 7, however, extremely same behavior of resistive heating as compared with the total current density. Resistive heating start from 2.44 W/m^3 at the electrical potential equal to 0.287 V, resistive heating falls into 1.87 W/m^3 at 0.3 V then from this value of resistive heating begun to decrease with increase of electrical potential until reach in to 0.125 W/m^3 at 0.95 V.

8.Conclusion

The model of thin film display high value of total current density focused in middle of the arc and the dissipation of the total current density occur around sides of the model. Values of electrical field assist to develop resistive heating. At the electrical potential equal to 0.287 V, the value of the total current density explosively falls from 1.575 A/m^2 in to 1.4 A/m^2 and resistive heating falls from the maximum value 2.44 W/m^3 into 1.87 W/m^3.

Total current density and resistive heating shows same linear behavior exists with the electrical potential. At 0.3 V electrical potential values of the total current density and resistive heating begun to decrease with increase of electrical potential until reach in to minimum values 0.425 A/m^2 and 0.125 W/m^3 respectively at 0.95 V.

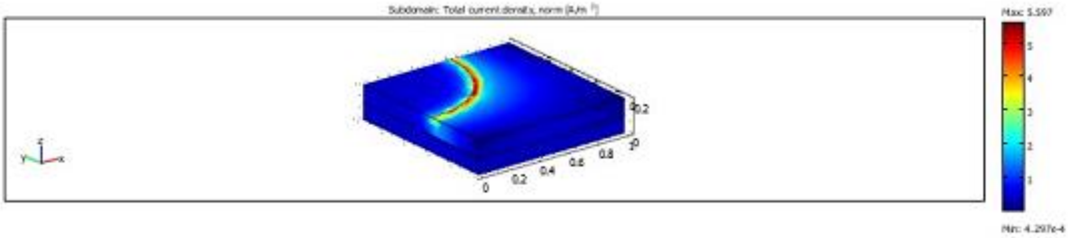


Figure. 3: Total current density

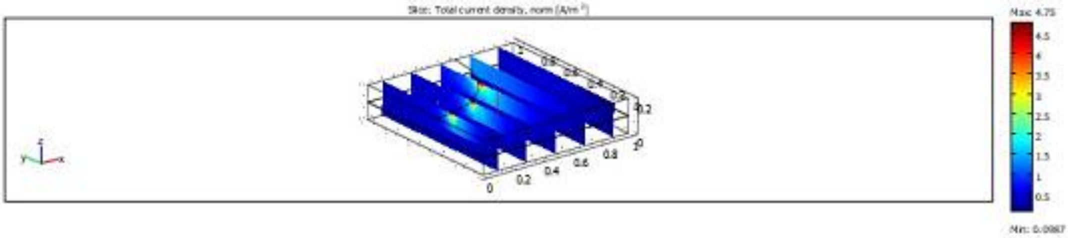


Figure. 4: Slice of total current density

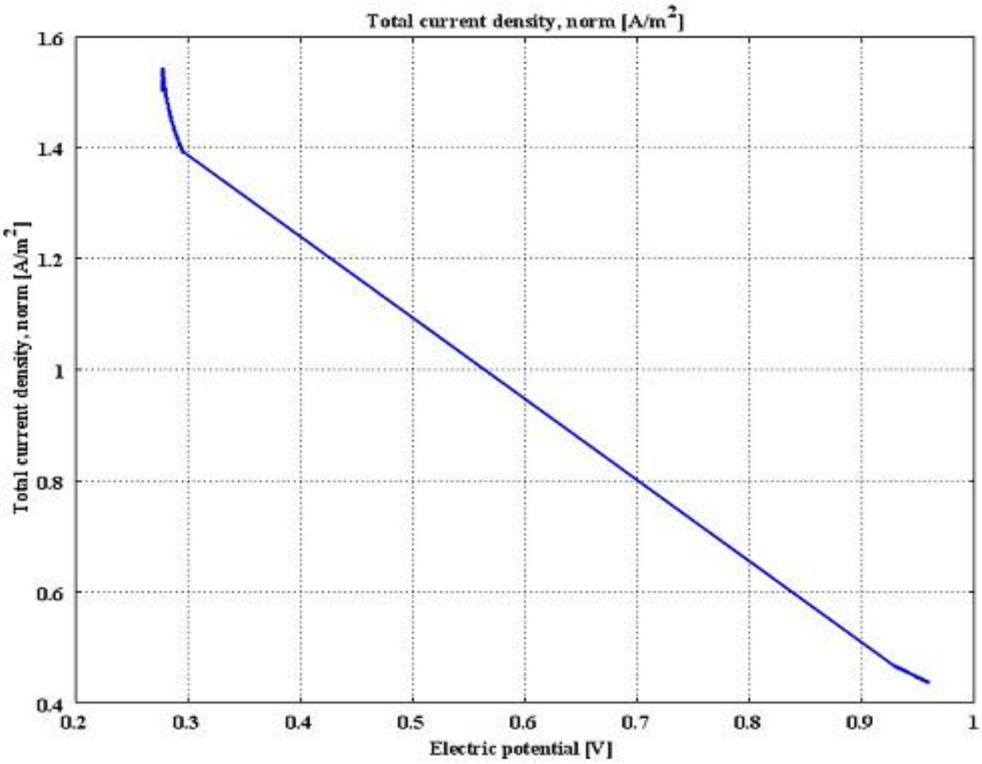
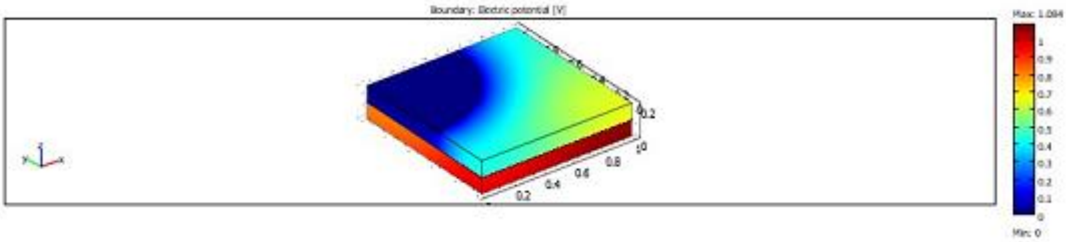


Figure. 5: Total current density



Figuer.6: Electrical potential

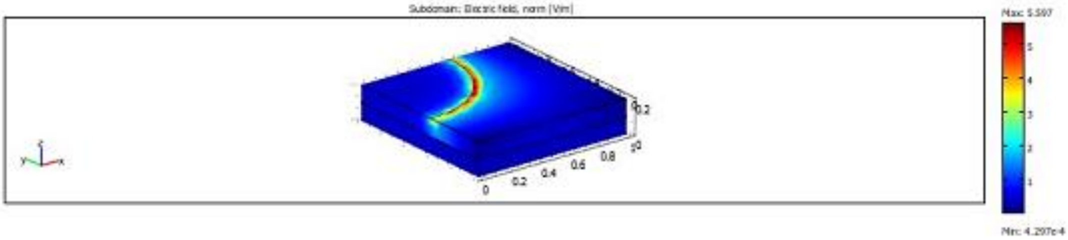


Figure. 7: Electrical field

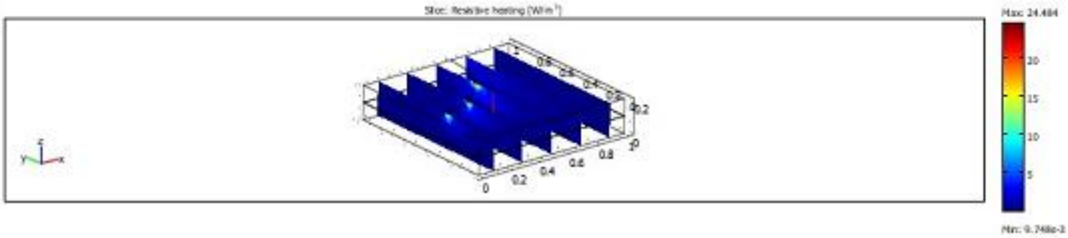


Figure 8: Slice of resistive heating

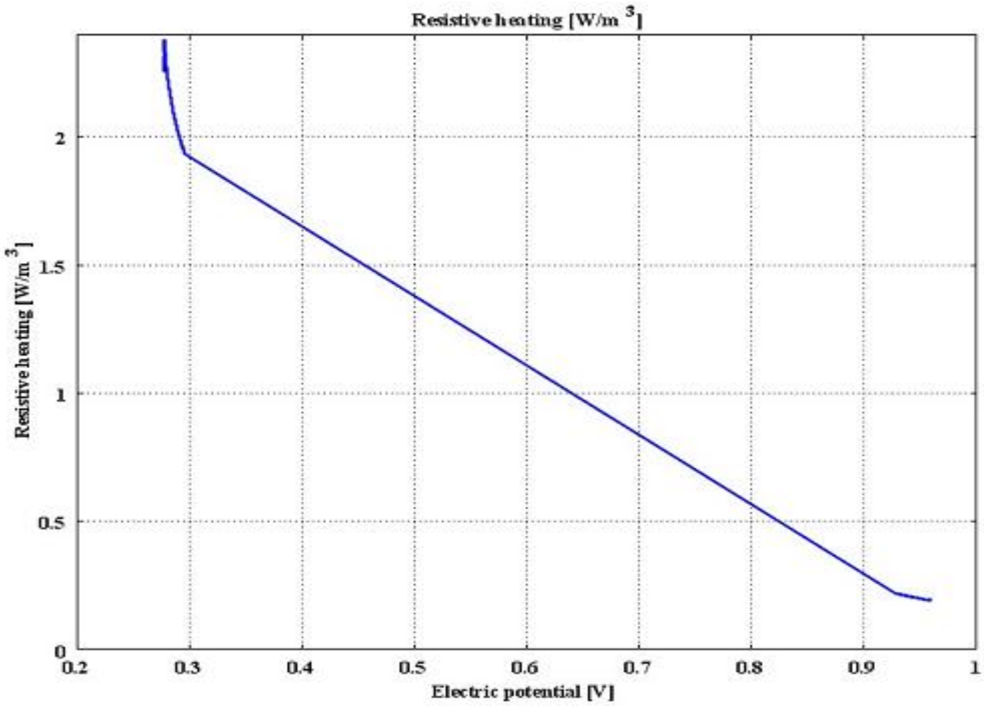


Figure. 9: Resistive heating

Conflicts of Interest

The author declares that they have no conflicts of interest.

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محاكاة خصائص الاغشية الرقيقة للشاشات التي تعمل باللمس

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الخلاصة

علوم وتكنولوجيا الأغشية الرقيقة تلعب دورا هاما في الصناعات ذات التقنية العالية. وقد تم تطوير تكنولوجيا الأغشية الرقيقة في المقام الأول بسبب الحاجة الماسة لصناعة الدوائر المتكاملة . الطلب على تطوير أجهزة أصغر وأصغر وذات سرع عالية وخصوصا في الجيل الجديد للدوائر المتكاملة حيث يتطلب مواد متقدمة و تقنيات معالجة جديدة مناسبة ومتفقة مع تكنولوجيا لمستقبل giga scale integration (GSI) technology . ومن اهم التطبيقات العملية لتكنولوجيا الاغشية الرقيقة هي الشاشة التي تعمل باللمس ، ولغرض المعرفة بهذا العلم يتطلب تحديد طبيعة ووظائف و خصائص جديدة من الأغشية الرقيقة يمكن استخدامها لتطوير تكنولوجيا جديدة للتطبيقات المستقبلية. يقدم هذا البحث محاكاة عددية تقريبية لنمذجة طبقة رقيقة مع التوصيل المباشر للتيار الكهربائي.

النمذجة والمحاكاة العددية المقدمة في هذا البحث لاتقتصر على تحليل ونمذجة تطبيقات الاغشية الرقيقة بل يمكن توضيفها لحل مشاكل التوصيل الحراري وانتشار المواد في الوسائط المسامية وتطبيقات فيزيائية اخرى باستخدام قانون دارسي .النتائج التي تم التوصل اليها من خلال هذا البحث تضمنت ايجاد شدة التيار الكهربائي خلال الاغشية الرقيقة والتيار الكلي على طول خمسة شرائح متوازية في الاغشية الرقيقة وكيفية تغير الفولتية نسبة الى شدة التيار خلال الاغشية الرقيقة اضافة الى دراسة سلوك المجال الكهربائي خلال الاغشية الرقيقة

الكلمات الداله: خصائص الاغشية الرقيقة، تطبيقات الاغشية الرقيقة