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DESIGN CONCEPT OF MOBILE STATIC DISCHARGER FOR HUMAN BODY ELECTROSTATIC DISCHARGE USING VAN DE GRAAFF'S GENERATOR

Soo King Lim[a*], Chong Yu Low[b], Koon Chun Lai[b]

[a]Lee Kong Chian Faculty of Engineering and Science, Universiti Tunku Abdul Rahman, Jalan Sungai Long, Bandar Sungai Long, Cheras, 43000 Kajang, Selangor Darul Ehsan, Malaysia
[b]Faculty of Engineering and Green Technology, Universiti Tunku Abdul Rahman, Jalan Universiti, 31900 Kampar, Perak Darul Ridzuan, Malaysia

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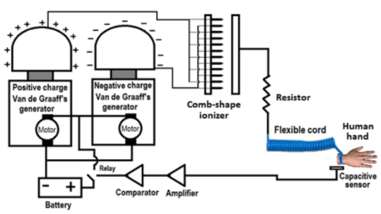
*Corresponding author
drsklim@live.com

Graphical abstract



Abstract

The damage of electrostatic discharge (ESD) is a well-known problem in the semiconductor industry. When human body (operator) is in contact with electrostatic sensitive semiconductor device during manufacturing process, damage to the oxide and other active parts of the device is caused by transferring of charge between device and human body. Semiconductor industry adopts preventive and protective approaches by grounding the human body with a wrist strap connecting to utility ground to neutralize the charge and setting up ESD preventive and protective workstation. Wearing a wrist strap is impractical for the operator and it causes psychological effect as the operator would not like to be strapped. A literature search and visit of many large semiconductor manufacturing facilities have revealed that there is no alternative mean used to neutralize charge from human body besides wearing a wrist strap. This paper presents a conceptual design of a mobile static discharger for human body electrostatic discharge using Van de Graaff's generator to generate equal amount of positive and negative charge cloud to neutral the charge of the operator. The conceptual design is a fool-proof design and it is viable to be implemented. It is also a design that will revolutionize the technique of electrostatic discharge for human body in the semiconductor industry.

Keywords: Electrostatic discharge (ESD), semiconductor device, Human Body Model (HBM), Van de Graaff's generator, comb-shape ionizer

Abstrak

Kerosakan oleh discaj elektrostatik (ESD) adalah masalah yang terkenal dalam industri semikonduktor. Apabila badan manusia (pekerja) bersentuh dengan peranti semikonduktor yang elektrostatik sensitif semasa proses pembuatan, kerosakan kepada bahagian-bahagian aktif peranti dan pelapisan oksidanya adalah disebabkan oleh pemindahan caj antara peranti dan badan manusia. Industri semikonduktor mengamalkan pendekatan pencegahan dan perlindungan ESD dengan hentakan badan manusia dengan memakai tali pergelangan tangan yang menyambungkan ke tanah untuk meneutralkan caj sambil membentukan stesen kerja yang boleh mencegah dan melindung peranti semikonduktor dari kerosakan ESD. Memakai tali pergelangan tangan adalah tidak praktikal untuk pekerja dan pemakainya akan menimbulkan kesan psikologi secara ianya diikati. Dari carian kesusasteraan dan lawatan kekebanyakan kilang pembuatan semikonduktor yang besar telah membuktikan bahawa tiada lain alternatif yang digunakan untuk meneutralkan caj dari badan manusia selain dari memakai tali pergelangan tangan. Kertas kerja ini membentangkan sebuah reka bentuk yang berkonsep pelepas statik mudah alih untuk discaj elektrostatik oleh badan manusia dengan menggunakan penjana Van de Graaff di mana penjana ini akan menjanakan caj positif dan negatif yang sama amuan untuk meneutralkan caj daripada pekerja. Reka bentuk konsep tersebut adalah reka bentuk "fool-proof" dan ia boleh diguna pakai untuk pelaksanaan. Ia juga merupakan satu reka bentuk yang akan merevolusikan teknik discaj elektrostatik untuk badan manusia dalam industri semikonduktor.

Kata kunci: Discaj elektrostatik (ESD), peranti semikonduktor, Model Badan Manusia (HBM), Penjana Van de Graaff, ionizer sikat

1.0 INTRODUCTION

Electrostatic Discharge Association states ESD accounts for 4 to 6 percent of annual gross sales loss. Besides, it constitutes about half of silicon integrated circuit and one quarter of gallium arsenide integrated circuit field failures [1, 2]. Thus, ESD phenomenon should be well studied and understood before effective control can be implemented to reduce or eventual elimination of this failure type.

The ESD damage can be modelled mainly by two models, namely human body model (HBM), and charged device model (CDM) [3]. Machine model (MM) has been discontinued rapidly due HBM at the device level since it produces the same failure mechanisms and the two models generally track each other in robustness and in failure modes produced [4].

Human body model has been extensively used to evaluate the cause of ESD since human handling is recognized as the most significant contributor of ESD damage besides machine used to process the device.

The basic principle of charge generation is by the contact and separation of two insulators. The results of contact and separation, one material would acquire electron and the other one would lose electron or vice versa depending on their work functions [5, 6]. Material with high work function tends to gain electron, while material with low work function would lose electron. Examples of contact and separation activities by human body that would create charge are walking, sitting, and standing up from seated position due to human body loses electron to the contacting material.

Electrostatic discharge is a phenomenon in which charge is discharged through human body or other conductor of higher potential to material of lower potential. The shock we feel when we touch a doorknob is an ESD event of about 3,000V due too short the discharge time to conductor. The freaking sound that we heard is due to corona breakdown of nitrogen and oxygen molecules.

2.0 CURRENT CONCEPT OF NEUTRALIZATION CHARGE FROM HUMAN BODY MODEL

ESD control has become part of the routine requirements for semiconductor manufacturing environment. Wrist strap is the primary means of controlling static charge on operator. When it is being properly worn and connected to ground via a 1.0MΩ resistor, the charge on the operator is neutralized with the electron from Earth ground keeping the voltage potential of the operator closed to zero volt and at the same time control the discharge time such that the operator would not feel the electrical shock. Unfortunately, it is not practical for operator to wear wrist strap while in standing or walking position.

3.0 CONCEPTUAL DESIGN OF THE MOBILE STATIC DISSIPATER

A literature search has revealed that there is no mobile charge dissipater is being developed actively except one design developed in 1993 [7] utilizing an array of field emitters built from semiconductor material to discharge built up electrostatic charge from human body into ambient air. Although there such a design, it has been implemented in semiconductor industry due to cost and effectiveness. The visit of large microelectronic manufacturing facilities reviewed that wrist strap is still the principal method used to neutralize the charge generated by human body. In view of the issues mentioned there is a crucial need to develop a fool-proof mobile discharger to provide the mobility and at the same time discharging the static generated by human body.

This paper proposes a design concept of a mobile static dissipater for human body electrostatic discharge, which is shown in Fig. 1. The design consists of two main parts and other accessory parts. They are the positive and negative charge generators and comb-shape ionizer. The other parts are limiting resistor, flexible connecting cable, and control circuitry.

The charge generator can be designed using the design concept of a Van de Graaff's generator [8, 9], which was invented by Robert Jemison Van de Graaff. A small size generator about six inches can be built and powered by a battery so that they can be carried by operator to attain mobility. Proper selection of insulative materials following the properties of their work functions, two insulative materials such as glass and rubber can be used as the contact and separate materials to generate electron and two materials such plastic and nylon can be used to generate positive charge. Selection of other materials can be referred from the tribo-electric series of the materials [5, 10].

The comb-shape ionizer is designed with tungsten needles connected alternatively to the positive and negative charge generators. When the charge voltage attains more than 3,000 volts, corona discharge [11] would occur producing alternate positive and negative that forms positive and negative charge cloud. The electron is used to neutralize the charge from human body. In case, there is a chance human body acquired electron, the positive charge will neutralize the electron, otherwise positive charge will be annihilated in the air.

A 1.0MΩ resistor is used to control the discharge time to be within microsecond so that the operator does not feel the freaking shock during neutralization and at the same time protect operator in the event of short to utility power. The flexible connecting cable is used to connect the ionizer to human hand via a conductive wrist band for the ease of movement. The capactive sensor is used to sense the residual voltage in human body. The residual voltage is then amplified and compared with a threshold voltage to control the switch on/off of the Van de Graaff's generator. A threshold voltage of less than 100V can be set to switch off the charge generator. If residual voltage is greater than 100V then the charge generator is switched on to generate charge for neutralization.

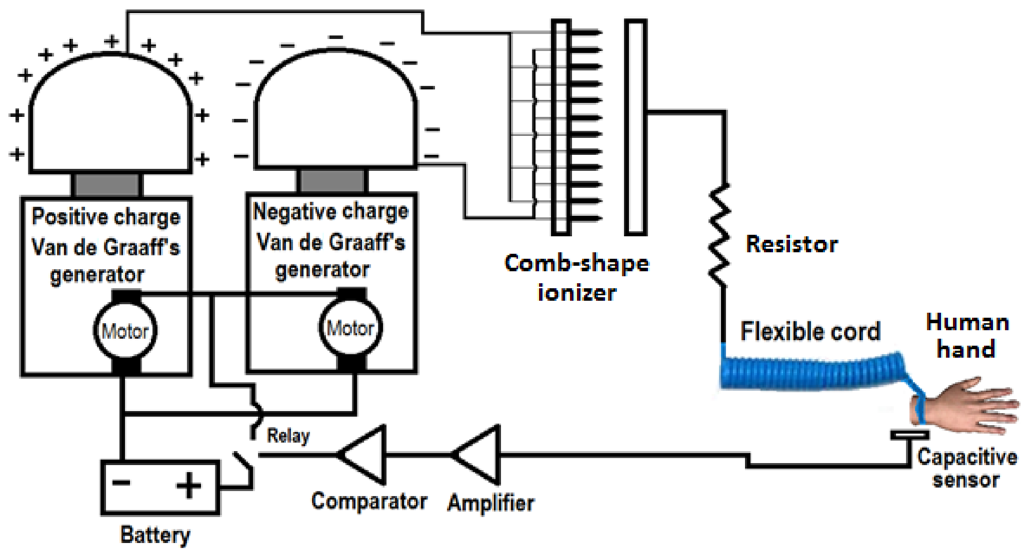


Figure 1 Design concept of a mobile static dissipater

4.0 CONCLUSION

The proposed design concept of a mobile dissipater can be implemented in semiconductor manufacturing industry to serve as the mean to neutralize static charge generated by the human body, instead of relying on impractical, non-fool-proof and non-flexibility way of neutralization of charge generated by human body via wrist strap connecting to Earth ground point. It is viable to design and use it to neutralize the charge from human body. It is also a design that will revolutionize the technique of electrostatic discharge for human body in semiconductor industry.

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