International Journal of Scientific Research and Engineering Development-– Volume 3 Issue 6, Nov-Dec 2020

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Characterization of Insulating Layer of Thermally Conductive Printed Circuit Board

Remesh Kumar K R*, K. Shreekrishna Kumar**

*(*School of Technology and Applied Sciences, Pullarikunnu Campus, Mahatma Gandhi University, Kottayam, Kerala, India*)

** (*School of Technology and Applied Sciences, Pullarikunnu Campus, Mahatma Gandhi University, Kottayam, Kerala, India*)

--************************----------------------------------

Abstract:

Size reduction of the electronic devices is not possible with huge heat sinks. In this paper, a thermally conductive Printed Circuit Board (PCB) that can also act as a heat sink isdiscussed. This strategy helps to reduce the device size by removing large heat sinks. Here, a thermally conductive baseis needed for making thermally conductive PCB. Boron Nitride (BN) is an electrically insulating material which is thin filmed on a copper plate using RF sputtering. Then the band gap of BN film is calculated by using UV-Vis spectroscopy and also determined the resistance of the films using source meter. From the results, it is evident that the RF sputtering do not affects the band gap of BN film and it possess very large resistance.

Keywords **—Boron Nitride films, RF sputtering, PCB, UV- Vis spectroscopy of BN films, electrical analysis..**

--************************----------------------------------

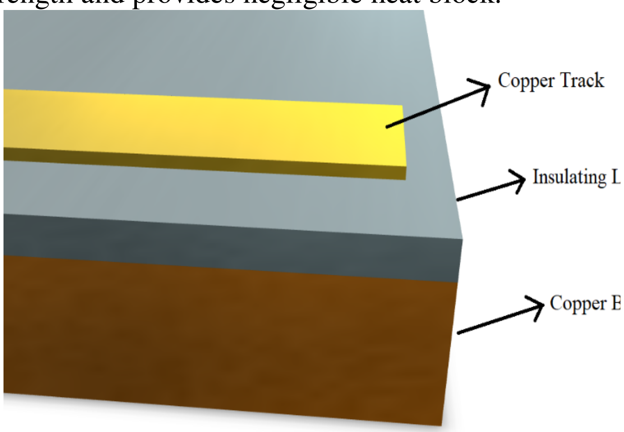
I. INTRODUCTION

Power electronics devices are handling high current and voltage. Such devices are used in many applications such as heavy industrial machines. Nowadays, the electronic devices are becoming very small hence it saves lot of room space. But power electronic devices [1], [2] are usually massive because of their thermal management. In this study, an effort is made to reduce the size of the large device by altering its rigid circuit board to a flexible one. The electronic components and circuits are inter connected using an insulating board called Printed Circuit Board (PCB) [3], [4]. Typically, PCBs are rigid because of its weight management system and current handling capacity. One of the main features of this type of rigid PCB is its capability for accommodating heat-sinks. If a rigid PCB is converted to flexible, one can't attach heat-sinks on it. Therefore, the aim is to avoid using these heat-sinks and introduce a new method for reducing the temperature of the components in the flexible PCB. In this study, a flexible PCB which conducts heat from components to the surrounding environment is developed.

In this study, for developing the heat conducting flexible PCB, a flexible copper sheet is used as a base layer, over which an insulating BN is coated. Copper conductive tracks are deposited on this insulating layer. The deposition technique to coat the BN film [5], [6] is RF sputtering [7]–[10] and deposition method used for copper deposition is thermal evaporation. The current and voltage carrying capacity are carried out for testing the efficiency of proposed PCB. Also, the UV-vis absorption is done for finding the bandgap energy of the BN.

II. METHOD OF STUDY

Figure 1 represents the proposed model of the PCB. The structure contains 3 layers: copper track, BN layer and copper base. The heat generated from the components are passed through insulating BN layer and reaches to copper base. The copper base transfers this heat to surrounding air. The BN insulating layer gives very high electrical insulation strength and provides negligible heat block.



A. Figure 1: 3D model of proposed PCB

Two examination are done in proposed PCB structure: UV-vis analysis and electrical analysis.

In the UV-vis spectroscopic analysis, the absorption spectra of the BN layer after RF sputtering is obtained. The main purpose of this analysis is to examine how the RF sputtering affects the properties of the BN material. For the analysis of RF sputtered BN film, 100nm h-BN film is fabricated. The chamber used for sputtering is initially pumps down to 0.007 bar pressure and applied 180w of RF power to the magnetron. It will take 10 minutes for the fabrication of 100nm BN film.

For electrical analysis the BN is coated over the copper sheet and then copper is coated above the BN layer. The source meter probe is connected to the copper base and the coated copper track. The source meter's voltage is varied from 0 v to 20 v and the value of current flow through track is measured. Using these measured current values and voltage, a V-I graph is plotted and the resistance of the layer is calculated.

III. RESULT

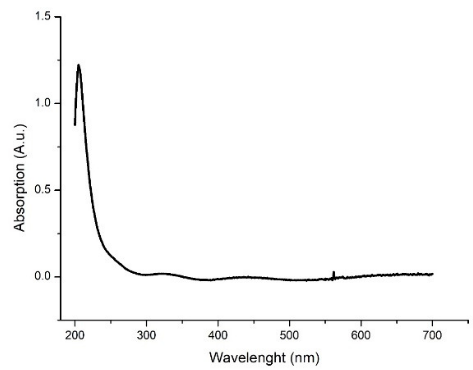


Figure 2: UV - vis absorption graph of BN layer

From the results, the wavelengths at which peak absorption occurred is at 100 nm. The absorption wave length and absorption peak of 100nm films is 203nm and 1.63228 respectively. From the graph, the bandgap energy of the BN film can be calculated[11]–[13]. The band gap of BN film of 100nm thickness is taken because, the properties such as band gap energy gets changed due to the RF sputtering. Figure 2 shows the UV spectra of 100nm film of BN. The band gap energy of the insulating material is found out from UV – vis absorption data using equation 1.

$$E= hc/\lambda \quad (1)$$

In equation 1, E is the band gap energy, h is the plank's constant c is the speed of light and λ is the absorption peak. Using the values from UV-vis analysis the value of band gap is calculated. The value of band gap is 5.99 eV.

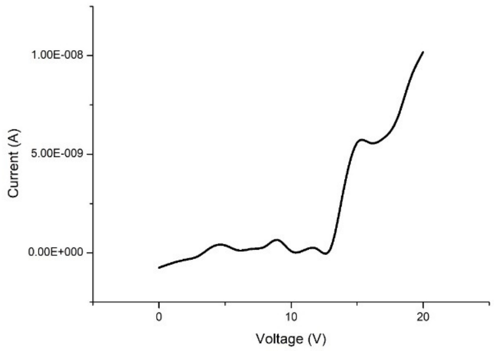


Figure 3: V-I characteristics of the BN layer

From the electrical analysis of h-BN layer, V-I characteristics is plotted using values from source meter. The V-I analysis shows that the voltage increases as the current through the BN layer increases. But this current is very small and it is in the range of nano amperes. But after 13V the current rises sharply due to the layer breakdown. The resistance of the BN layer is calculated as 4.4 Giga Ohms which is very large and it is enough for an insulating layer in the proposed thermally conductive PCB. Figure 3 shows the V-I characteristics of BN layer.

IV. CONCLUSIONS

The electrical, UV-Vis absorption and band gap energy properties of the BN film are not changing with RF sputtering. Therefore, RF sputtered BN layer can be used as an insulating layer in high power circuitry. The main drawback of RF sputtering is, it can be used only for small area of coating. Also, the rotation of the substrate helps to get uniform thin film. In future studies, the XRD and SEM analysis helps to identify further structural variation and surface properties of the BN film. The RF sputtering is a physical vapour deposition method and hence it avoids the usage of dangerous chemicals. Thus, it is an eco-friendly and low-cost fabrication technique.

REFERENCES

[1] R. W. Erickson and D. Maksimovic, *Fundamentals of Power Electronics*, 2nd ed. Springer US, 2001.
[2] A. M. Trzynadlowski, *Introduction to Modern Power Electronics*, 3rd ed. Wiley, 2015.
[3] R. S. Khandpur, *Printed Circuit Boards: Design, Fabrication, Assembly and Testing*, 1st ed. Tata McGraw-Hill, 2005.
[4] M. I. Montrose, *EMC and the Printed Circuit Board: Design, Theory, and Layout Made Simple*. Wiley, 2004.
[5] A. Goswami, *Thin Film Fundamentals*, 1st ed. New Age International Pub, 1996.
[6] L. B. Freund and S. Suresh, *Thin Film Materials: Stress, Defect Formation and Surface Evolution*. Cambridge University Press, 2004.
[7] S.swann, "Magnetron Sputtering," *Power*, vol. 67, pp. 1–27, 1996.
[8] G. Bräuer, B. Szyszka, M. Vergöhl, and R. Bandorf, "Magnetron sputtering - Milestones of 30 years," *Vacuum*, vol. 84, no. 12, pp. 1354–1359, 2010.
[9] I. Safi, "Recent aspects concerning DC reactive magnetron sputtering of thin films: a review," *Surf. Coatings Technol.*, vol. 127, no. 2–3, pp. 203–218, 2000.
[10] P. . J. Kelly and R. . D. Arnell, "Magnetron sputtering: a review of recent developments and applications," *Vacuum*, vol. 56, no. 3, pp. 159–172, 2000.
[11] K. Ba, W. Jiang, J. Cheng, J. Bao, N. Xuan, and Y. Sun, "Chemical and Bandgap Engineering in Monolayer Hexagonal Boron Nitride," *Nat. Publ. Gr.*, pp. 1–8, 2017.
[12] V. L. Solozhenko, A. G. Lazarenko, J. Petitet, and A. V Kanaev, "Bandgap energy of graphite-like hexagonal boron nitride," vol. 62, pp. 1331–1334, 2001.
[13] K. Watanabe, T. Taniguchi, and H. Kanda, "Direct-bandgap properties and evidence for ultraviolet lasing of hexagonal boron nitride single crystal," *Nat. Mater.*, vol. 3, no. June, 2004.

