«Saint Petersburg OPEN 2018»

BOOK of ABSTRACTS

5th International School and Conference on Optoelectronics, Photonics, Engineering and Nanostructures

April 2-5, 2018 • Saint Petersburg, Russia

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Academic University Publishing
St. Petersburg, 2018

5th International School and Conference "Saint Petersburg OPEN 2017" on Optoelectronics, Photonics, Engineering and Nanostructures carries on the tradition of annual conferences and schools organized at St Petersburg Academic University for students, PhD students and young scientists. The School and Conference is established and chaired by Nobel Prize laureate in Physics academician Zhores Alferov.

More detailed information on the School and Conference is presented on *http://spbopen.spbau.com/*

The Book of Abstracts includes abstracts of contributed works accepted for presentation at the Conference.

The volume was composed by St. Petersburg Academic University from electronic files submitted by the authors. Only minor technical corrections were made by the composers.

Chief Editor: Zh. I. Alferov
Editors: A. E. Zhukov, V. V. Korenev

Published by
St. Petersburg Academic University, Khlopina 8(3),
194021 St Petersburg, Russia
Printed in Russian Federation

Organizer

St Petersburg Academic University

Acknowledgements

Peter the Great St Petersburg Polytechnic University

SPIE. STUDENT CHAPTER
SAINT-PETERSBURG ACADEMIC UNIVERSITY RUSSIAN ACADEMY OF SCIENCES

IOP Institute of Physics

Crystal growth and structural properties of nanostructures

Increase of accuracy of capacitance parameters measurements of power semiconductor modules on base IGBT and FRD

D A Knyaginin, A Yu Drakin, S B Rybalka, A A Demidov
Bryansk State Technical University, Brynask, 50 let Oktyabrya 7, Russia

Abstract. This investigation presents an overview of questions related to the increase in accuracy of measurements of capacitance parameters of power semiconductor modules when developing a device for automated measurements. Result addresses the matters of circuit engineering of primary components, technical characteristics and software of a meter designed to automate the process of testing of capacitance parameters of power modules based on IGBT (insulated gate bipolar transistors) and FRD (fast recovery diodes). Unit testing results that prove the efficiency of the proposed method of the technical implementation are studied. Software implementation is described; ways to improve software-hardware solution are proposed. The obtained results can be used for automated testing of electric parameters of power semiconductor devices.

1. Introduction

The national standard and programs for in-process and final control of electrical parameters provide for measurements of input and output capacitance of IGBT and the total capacitance of FRD in the course of manufacturing of IGBT- and FRD-based semiconductor modules. That said, the desired measurement range of capacitance is usually 50 pF–50 nF; while frequency of the current used for measurements shall be 1 MHz. The above-mentioned development environments were analyzed in the context of this research which implies the development of original open hardware and top level software. For the purpose of testing process control, MATLAB was selected as the product which has no FRD total capacitance shortcomings, as compared to peers, within the framework of this application-oriented measurement task.

2. Materials and methods

In order to eliminate problems which arise during the "remote" measurements of capacitance parameters of power modules, a method similar to [1] is proposed here. The essence of this method is clarified by the circuit diagram (Figure 1) using measurements of IGBT input (a) and output (b) capacitance as an example. The proposed method for measuring capacitance parameters of IGBT and FRD was implemented in the capacitance parameters measuring unit which is controlled by the external computer system. Also, this unit functions as a part of the equipment for automated parameter testing of the IGBT- and FRD-based power semiconductor modules. In order to use the capacitance parameters measuring unit as a part of the automated testing equipment within the local information network, an individual address for the controller can be assigned by means of microswitches. In terms of design, the capacitance meter was executed as a unified device and contains functional nodes in the form of printed modules as shown in the diagram. Serial converter AC/DC of Hengfu Corporation 25W Open Frame Switching Power Supply HF25W-SPL-12 was used as a converter of the mains AC

voltage into the intermediate DC voltage. The authors developed and made the remaining modules. The unit provides for the measurements of capacitance from 50 pF to 50 nF in the below three sub-ranges: 50–500 pF, 500–5000 pF, and 5–50 nF. The sub-range used for the generation of the final result is selected automatically.

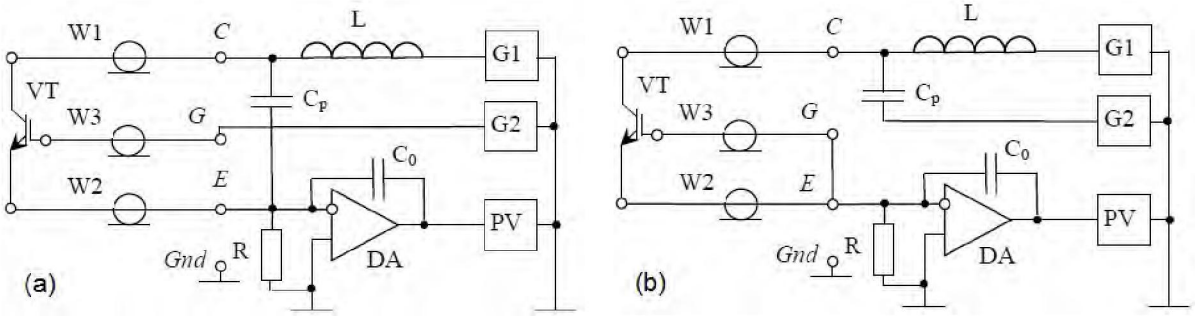

Figure 1. a) diagram for measuring IGBT input capacitance; b) diagram for measuring IGBT output capacitance.

3. Results and discussion

It is established that in the measuring converter circuit (Fig. 1ab) the frequency characteristic of the optimum amplitude should be performed to ensure the stability of operation within measurement sub-ranges 500 – 5000 pF and 5 – 50 pF. These findings do not fully conform to the results of the device modeling in NI Multisim 12.0 environment [2,3]. It was experimentally shown that it is possible to perform such correction by connecting a low-ohmic resistor in series with the reference capacitor C circuit resistance on the frequency of 1 MHz does not basically change, which facilitates the process of calibration of the meter. The testing result is similar with [3,4] and indicatives of the efficiency of the proposed method remote measurement of the IGBT/FRD capacitance parameters in case of small values of the measured capacitance and relatively big distance between the meter and IGBT/FRD.

4. Conclusions.

The proposed method of remote measurement of capacitance parameters can be applied not only in the automation systems to test parameters of semiconductor devices but also in other spheres, for example, during the development of capacitance sensors. The results it is possible to use behavioral models based on experimental data in automated test systems because little attention is given to temperature dependent effects of capacitance parameters in the available theoretical models. The study is relevant and important because the task of automation of the testing of electrical parameters of power semiconductor modules (IGBT, FRD) at the manufacturing stage is very common today.

Acknowledgements

This work has been supported by the Russian Ministry of Education and Science (task No. 8.1729.2017/4.6).

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