

OPPONENT'S REVIEW OF THE DISSERTATION THESIS

Title of the thesis: **Dielectric Properties of Thin Tantalum and Niobium Oxide Layers**

Author: **Ing. Inas Fasel Abuetwirat**

The dissertation thesis of Mrs. Inas Fasel Abuetwirat deals with an interesting and topical problem of the evaluation of the dielectric properties of thin Tantalum and Niobium oxide layers. With its central topic, the dissertation thesis belongs to the study branch of physical electronics and nanotechnology. The purpose of thesis was to investigate dielectric relaxation spectra and conductivity of tantalum and niobium oxides in wide frequency and temperature range. Author analyzes the frequency and temperature response of capacitor samples on base Ta and Nb oxides from point of view behavior dielectric relaxation spectroscopy. Dielectric relaxation spectroscopy is more sensitive to intramolecular interactions, which allow a better understanding of dielectric system properties and attempt to determine the origin of the relaxation. This is the reason why I consider dissertation thesis submitted to be topical.

In introductory parts of her dissertation thesis, the author deals with problems related to basic principles of dielectric relaxation spectroscopy and explains individual models used in dielectric relaxation spectroscopy as well as various potential approaches within the framework of various transformations. In this well-prepared and easy-to-understand part of the dissertation, the author has proved his abilities to present a physical method in a relatively limited space which was available. In this part of the thesis there is a detailed description of electrolytic capacitors. Author presents the features of construction of tantalum oxide and niobium oxide capacitors and its electrical performance.

The experimental part of dissertation work describes measuring methods and the equipment used for the measurement of dielectric properties in a wide temperature interval. Here I have some questions to the author:

- Why was in experimental work used silicon temperature sensor and not another type?
Did the author deal with the problem of the effect of contact leads upon the actual temperature of the sample?
- What about the accuracy of temperature setting in the course of the measurement and how high was temperature linkage between measured sample and temperature sensor?

The submitted thesis contains originally contributed results, given in chapter 7. In this part of dissertation thesis there are presented the original results and analysis of dielectric properties of thin Tantalum and Niobium oxide layers.

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The new findings established in this dissertation paper include mainly :

- Establishment of the fact that in conductivity spectra, Ta_2O_5 exhibits a steady increase in the low frequency mode and that above a characteristic frequency, the conductivity increases with increase in frequency with characteristics power ($\wedge n$) dependence, where the onset of the increase of conductivity with frequency depends on temperature,
- Experimental confirmation that the relaxation peak keeps its position and magnitude irrespective of the thickness of the dielectric layer, so that bulk properties are probably not responsible for it,
- Suggestion that the low frequency behavior of the relaxation peak could be attributed to an electrode polarization mechanism related to the accumulation of mobile charges at electrodes.

The author published main results performed in dissertation thesis in original papers and in scientific conferences proceedings.

Regarding the dissertation thesis as a whole, I have the following comments or rather questions:

- Why did not you carry out measurements of dielectric parameters of samples over the declared maximum or minimum standard operating temperatures?
- Can you explain meanings of parameters α and β in general and in this work?

I also have a few more comments, which are listed below, however these are of less severe significance and they do not affect my total positive assessment.

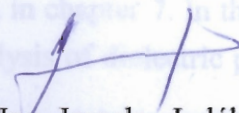
Comments:

- p. 18 Boiling point of Tantalum is $3017\text{ }^\circ\text{C}$?
- p.18, 19 Body centered cubic lattice is in short (bcc)
- p. 20 Please explain "Conductivity of Nb_2O_5 is about $10^{-16} - 10^{-6}\text{ S/m}$ "
- p. 32 Please explain equation (3.24)
- p. 72, 83,84 equation (90) , Figure 56, 58 ?

In conclusion, it is possible to allege, that the dissertation thesis submitted by the PhD student Mrs. Inas Fasel Abuetwirat represents a contribution to a better understanding of the dielectric properties of thin tantalum and niobium oxide layers.

After the assessment of the work presented of the scientific and research results attained and after the successful defense, I recommend Mrs. Inas Fasel Abuetwirat to be awarded by the academic degree „**Philosophiae Doctor**“, in short **PhD**.

In Bratislava, November 25th, 2014


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