CHARACTERIZATION OF LOCALLY AVAILABLE MICA MINERALS FOR CAPACITOR APPLICATIONS

Thise Appuhamilage Erangi Indika Siriwardhane

(139462P)

Degree of Master of Science

Department of Materials Science and Engineering

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FEBRUARY 2019

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Thesis/Dissertation submitted in partial fulfilment of the requirements for the degree

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Declaration

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institution of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate has carried out research for the partial fulfilment of the requirements for the Degree of Master of Science in Materials Science and Engineering under my supervision.

Name of the supervisor: Prof. S U Adikary

Signature of the Supervisor: Date:

ACKNOWLEDGEMENT

I would like to express my deepest appreciation to all those who provided me the possibility to complete this project. I am greatly indebted to Sri Lanka Standards Institution (SLSI) for sponsoring me to follow this M.Sc. programme and granting leave when necessary in completing this project.

I would like to express my heartfelt gratitude to the supervisor of my research, senior lecturer of Department of Materials Science and Engineering, Prof. S U Adikary, for his untiring reviews, prompt feedback and unwavering guidance. I would like to express my sincere thanks to the senior lecturer of Department of Materials Science and Engineering and our research coordinator Dr. Santha Amarasinghe, for his valuable advices and guidance given throughout this study. I would deeply thankful to all academic and technical staff members of Department of Materials Science & Engineering to their support given to me while I am carrying out this study.

I also acknowledge, Dr. (Mrs.) Iresha Kottegoda, Principal Research Scientist, Materials Technology Section of Industrial Technology Institution (ITI), for her valuable support.

Furthermore, I would also like to acknowledge with much appreciation the crucial role of the staff of Industrial Technology Institution (ITI), to conduct experiments, especially Ms. Dilini Colombage for SEMs and Mr. Sujith Karunadasa for XRDs. Special thank goes to Dr. Sandun Dalpathadu, Managing Director of Polyzon Industries (Pvt) Ltd., who provided me all the samples, from different locations in Sri Lanka.

Also I would like to thank Mr. T G G Dharmawardena, former Director General of SLSI, and Mr. Kapila Abeygunawardane Senior Deputy Director (Engineering Standardization) for their endless encouragement and invaluable support given to me throughout the study to succeed this research.
My special thanks go to my parents and my family members for the moral support they have given to me to success this study.

Abstract

Mica is a group of minerals of the hydrated alumino silicate of iron, magnesium, potassium, lithium and sodium etc. Commercially, the two most widely used micas in the electrical industry are the muscovite and phlogopite types. Phlogopite is the widely available mica type in Sri Lanka.

Micas from different mining locations (Mathale, Mailapitiya, Badulla and Kebethigollewa) in Sri Lanka were characterized using XRD and SEM methods. Two different methods, namely ceramic method and flake method were used to study the dielectric properties of locally available mica. Dielectric behaviour of mica characterized above has been investigated by measuring capacitance (C) and loss tangent (D) at selected frequencies, with a precision LCR meter in a controlled environment. Then the relative permittivity, ε_r for each specimen was calculated and behaviour of ε_r with frequency was studied. Five flake specimens each obtained from four different locations and five ceramic disc specimens each prepared with powdered mica of two different locations were used for the study. Size, shape and method of preparation of the specimens were kept constant throughout the experiment. Graphs between ε_r and $\log_{10}$[frequency] of silvered mica flakes, and that of silvered mica discs were plotted separately. Accordingly, samples prepared by both methods have also been compared. Finally, average loss tangent D_{avg} values of silvered mica were plotted as a function of average relative permittivity, $(\varepsilon_r)_{avg}$ at defined frequencies and investigated location wise.

Scanning Electron Microscopic (SEM) analysis of Mathale and Mailapitiya samples confirmed that they have typical mica like flaky structures with layers. The XRDs of mica samples from different locations revealed different crystal structures & poly types. Sample from Mathale revealed two crystal structures Phlogopite 1 M and Phlogopite 3T, while Mailapitiya sample revealed two crystal structures Phlogopite 1 M and Biotite. Phlogopite 1 M and Hendricksite (Zinc- rich mica) were found fairly abundantly and Wustite ($Fe_{0.92}O$) was found in small concentrations in Badulla sample, while Phlogopite 3T was found abundantly in Kebethigollewa sample.

Dielectric properties including dielectric constant (ε_r) and dielectric loss tangent (D) have been done in the frequency range from 1 kHz to 1MHz. The results showed that the dielectric constant (ε_r) and loss tangent (D) decrease with the increasing frequency at room temperature. As per the results, Kebethigollewa flake mica and sintered Mathale mica were the best types with higher ε_r and lesser D, at low radio frequency ranges. However, flake mica showed comparatively higher ε_r values than that of mica dielectrics obtained from the same source and manufactured by ceramic method. These results are also found compatible with the results of similar studies carried out by the researches in different countries.

Hence, it can be concluded that locally available mica can be applied as dielectrics for capacitors within low radio frequency range. Even though both methods can be used, flake method is more suitable for applications which require higher ε_r values while ceramic method is better, where low capacitance applications are required. Ceramic method may be further developed by using other techniques such as slip casting method. Kebethigollewa and Mathale mica flakes are the best sources in terms of dielectric properties.

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