Analysis on the Electrical Properties of Syntactic Foam Under Various DC Field Stresses

Abstract— This study deals with the experimental investigation on syntactic foam, a new composite insulation material consisting of an epoxy resin matrix filled with hollow glass microspheres, which is an advantageous material for the use in compact and light high voltage dc applications. The investigations carried out focus on the impact of homogeneous dc field stresses on the material's electrical properties in short and especially in long term timescale. The values of the breakdown field strength and the specific volume conductivity provided here are essential for the use of syntactic foam in high voltage dc components.

I. INTRODUCTION

The design of several high voltage dc applications requires an exceptionally light and compact insulation system (e.g. for the use in rotating equipment). Syntactic foam, a rigid composite dielectric, provides the best combination of compactness, light-weight and high breakdown strength for this kind of applications. Syntactic foam consists of microscalic hollow glass microspheres, which are mixed into an epoxy resin matrix, in order to achieve a foam-like structure. The material's name origins from the materials structure, which differs from the structure of conventional foamed polymers. The mechanical and electrical properties of the syntactic foam can be predefined by varying the filler size, type and volume percentage. On the basis of syntactic foam a commercialized insulation system for encapsulated high voltage dc equipment was designed. Ongoing investigations focus on the impact of diverse dc field stresses on the breakdown process and the field distribution of syntactic foam. Fig. 1 shows a Scanning Electron Microscopy (SEM) picture of a cutting area of the material.

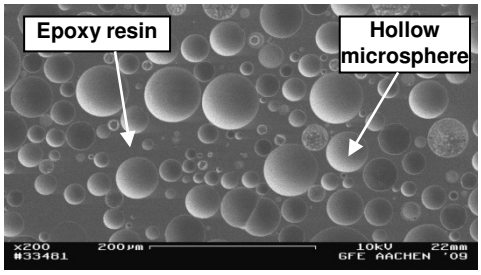

Figure 1. SEM picture - inner structure of syntactic foam

The electrical deterioration process in syntactic foam is analyzed in general by [1]. The breakdown field strength for short term static dc stress is given. In many applications, however, the high electrical dc field is applied as a step function. This causes transient processes with duration of several minutes and hours inside the insulation system. The present study focuses on the detailed investigation of the short term transient behavior and the long term breakdown field strength of syntactic foam. Moreover, the consideration of the microscopic field distribution inside of syntactic foam is used to analyze the breakdown mechanism.

II. RESULTS OVERVIEW

In the experiment, different types of syntactic foam are stressed with step function voltage, causing transient processes to take place inside the material. The materials' conductivities are determined by measuring the volume current. Additionally, the dependency of the breakdown field strength on the transient properties of syntactic foam is determined. The consideration of the microscopic field distribution inside syntactic foam during the transient process is used to analyze and extend the breakdown mechanism of syntactic foam.

The breakdown field strength in the long term test is investigated for durations up to 5000 h. The time to breakdown for field stresses of 16, 18 and 20 kV / mm is given. The time to breakdown decreases, if the electrical stress on syntactic foam is increased. Additionally, the impact of the stressed material's volume on the short term breakdown field strength of syntactic foam is investigated. For electrode distances above 3 mm an increase of breakdown field strength is observed.

The combination of the determined transient conductivity curves and conductivity values after the transient process is finished provides all the required data to analyze the field distribution in insulation systems containing syntactic foam. The knowledge of these values is especially important for pulsed dc voltage applications and HVDC applications, where the high dc voltage is applied as a step function voltage.

The breakdown properties of syntactic foam enable the use of the material in high voltage components. The long term breakdown field strength as well as the dependency on the stressed material volume is given.

III. DOWNLOAD LINK

The synopsis of the study is available for download on www.ifht.rwth-aachen.de/EEIM_JNA2010_synopsis.pdf. The results of the study will be published as PHD thesis by Mainz Verlag in 2011.

IV. REFERENCES

[1] A. Tröger, Analysis of electrical breakdown mechanisms in syntactic foams, PHD-Thesis, Aachen, Aachener Beiträge zur Hochspannungstechnik, 2009

EEIM JOHN NEAL AWARD 2010 SYNOPSIS ABSTRACT
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