Syntactic foam as an alternative electrical insulation material for superconducting cable systems

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In superconducting equipment for electrical power distribution networks liquid nitrogen (LN2) based insulation systems are commonly used. In this case, liquid nitrogen simultaneously has got an insulating and cooling function. One disadvantage of these insulation systems is the bubble formation within LN2 due to heat losses of the current carrying conductor, which reduces the dielectric strength of the insulation system drastically. Furthermore, the significance of routine tests performed immediately after the production of the component is rather low when LN2 is released for delivery. Thus, the tests are repeated on-site after commissioning. An alternative to LN2 based insulation systems are solid insulation systems where LN2 has only got a cooling and no more an insulating function. Additionally, solid insulation systems can take mechanical functions.

This paper deals with syntactic foam as a solid insulation system, which can be an alternative to LN2 based insulation systems for superconducting power equipment. Syntactic foam consists of a polymeric matrix and embedded hollow microspheres (HMS) with mean diameters of several 10 µm. The embedded hollow microspheres feature a reduced thermal contraction, a lower density and a lower relative permittivity compared to the pure matrix material. Several syntactic foams are investigated regarding their dielectric strength under AC stress, their thermal contraction and their mechanical stability at liquid nitrogen. For this purpose, epoxy resin (ER) and unsaturated polyester resin (UPR) serve as matrix materials of the syntactic foam. The HMS used in this investigation are made of glass and silanized glass. By comparing the results of measurements at liquid nitrogen temperature with those at ambient temperature the influence of the temperature difference on the dielectric strength can be determined.

The results show that the dielectric strength decreases with increasing filling degree and the test temperature of 77°K features higher dielectric strengths than ambient temperature. Furthermore, the dielectric strength reaches peak values up to 53.9kV/mm. Fig. 1 shows the dielectric strengths of several syntactic foams based on ER and UPR with a filling degree of 50 percent of volume at ambient temperature (AT) and 77 K. Also the thermal contraction is influenced by the filling degree of HMS where higher filling degrees lead to lower contractions. By filling the polymer matrix with 50 percentage of volume with HMS the thermal length contraction can be reduced to 0.5%. The mechanical tests show that ER and syntactic foam based on ER induce young's moduli of about 4000 MPa which is about ten times higher than the young's moduli of UPR and syntactic foam based on UPR. The results presented in the paper will show syntactic foam as a promising alternative insulation material for superconducting cables and their accessories like terminations.

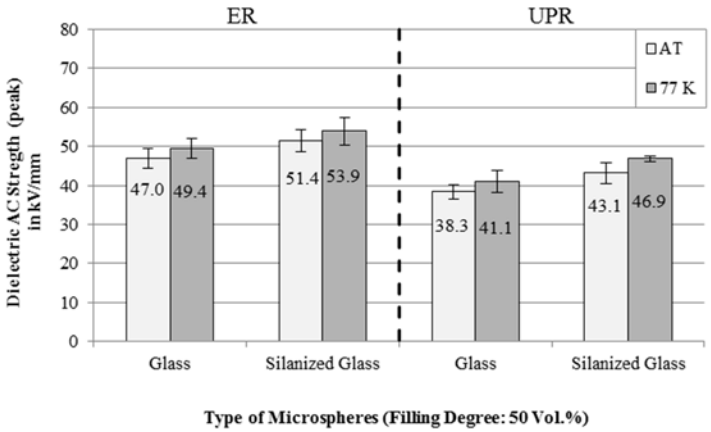

Fig. 1:.Dielectric strength of syntactic foam