# Electrical behaviour of current conducting silicon rubber

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***Abstract-*** **Conductive plastic gain more and more interest in electrical industry due to few advantages in comparison to metal like light weight and rustles properties and to some extent lower material price. The idea of using such materials is not new. These kinds of materials have been applied for many years in fields like electromagnetic shielding or voltage grading, where there strongly entrench his position. Recently new possible applications are being taking into consideration, which have in common that conductive plastic should conducting significant among of current. This paper inspects a mechanism of current conducting be means of percolation theory and resulting with that consequence.**

## I. INTRODUCTION

In order to achieve a very low résistance in plastic material, which are at normal state insulator it is necessary to add conductive fillers, which enhance electrical conductivity. The most commonly filler used for this purpose is carbon black. The reason for that are first and foremost the low price, rust-proof and opportunity to adjust the carbon black conductivity depending on combustion process [1]. A mixture of plastic and high conductive carbon black presents a new material, which exhibits various value of resistance according to percentage of conductive filler. The typical characteristic of conductive plastic is showed in figure 1. The dependency between resistance and carbon black concentration shows highly unlined characteristic, which could be elucidated by different physical processes namely mechanical tunnelling and percolation.

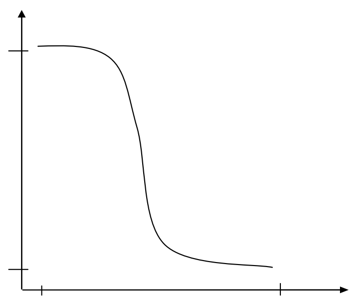

Figure1. Volume resistivity versus the carbon black content

## II. ELECTRON TRANSPORT IN CONDUCTOR-FILLED PLASTIC SYSTEMS

### A. *Quantum Mechanical Tunnelling*

If carbon black loading has a very small fraction then the electron transport is being conducted by means of so called tunnelling. For the conductive element, the conductance is merely its ohmic value. But for the insulating silicon rubber, matters are more complicated. Two conductive particles whose separation is large compared to atomic dimension see each other through a resistance controlled by the bulk resistivity of the silicon rubber itself. However, when the distance is small ($\leq$ 100 Å), electrons may tunnel quantum mechanically between conductive fillers, leading to a lower resistance than would be expected from the insulator alone. A comprehensive examination of normal quantum tunnelling can be found in Sheng. The basic concept in the Sheng proposal is that there exists across any tunnel junction a voltage that is sum of two pieces. One part is simply due to the externally applied source; the other part is contributes by quantum thermal fluctuations with the junction barrier [2].

### B. *Percolation theory*

For a small volume fraction of the conducting filler particles, the resistivity of composite is close to that of silicon rubber matrix (but not equal to due to above mentioned tunnelling process).As the volume fraction of the conducting filler particles increase, the particles come into contact with one another to form the conduction paths through the composite. As a result, the resistivity drops by many orders of magnitude at a critical threshold. One a saturation region of conducting filler particles is reached; there are a large number of conduction paths, resulting in a low resistivity [3]. This critical threshold where the resistivity so rapidly drops is called percolation threshold. The value of percolation threshold is no constant but depends of many factors and from one sample to another fluctuates. The factors, which contribute to this, are: size, aspect ratio, structure, allocation, roughness of carbon particles and kind of silicon rubber. Taking into consideration all this factors and precisely prediction of percolation threshold is a very difficult task. Generally it can be deduced that a high aspect ratio and high conductive chemical structure of fillers contribute to advantage of forming the conducting network, so that percolation threshold is lower.

## III. Result of current stress

### A. PTC Effect

The most significant result of current conducting through conductive silicon rubber was increase of resistance with temperature rise (see Fig. 2). Because black carbon has negative temperature coefficient of resistance, that means the resistant decreases with temperature increase, this effect must have an explanation in another material properties. A straightforward explanation is to ascribe the observed experimental facts to self-heating of sample. The thermal expansion coefficient of silicone rubber is 2.0-2,5 as big as other organic rubber ;meanwhile, the thermal conduction coefficient of silicon rubber is also very high, so, serious self heating results in increasing temperature of the sample [4].The thermal expansion coefficient resulting in volume expansion causes breakdown of conductive pathways what contribute to resistance increase.

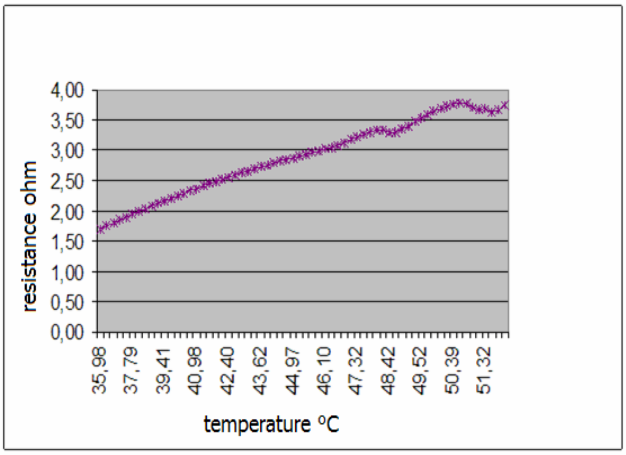


Figure2. Resistance of conductive silicon rubber as a function of temperature

This effect can be reduced at higher carbon black loading if the contact pressure will be applied. At higher carbon black loading, the conductive networks increase and the average interparticle gap becomes smaller. Therefore, the contact pressure of particle becomes higher and the network breakdown process becomes less efficient. As a result, the rate of increase in resistivity is reduced [5].

### B. Switching Effect

During high power switching material absorb high energy, which leads to partial material ablation. After the high energy impulse is terminate the material is capable of switching again. This is in contrast to the switching under low current density and voltage condition where there are no outward indications of this switching event.

## IV. Conclusion

Conductive carbon black composites have been researched in many respects including electrical conduction properties and dielectric behaviour. Because carbon black–silicon rubber obey different conduction mechanisms it is very important to know accurate and relevant characteristics. Because this material exhibit positive temperature coefficient the most feasible application can be associated with current limiter device.

## References

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