Sergei Wittchen
Minoj Gnanaseelan
Kristin Trommer

FILK Forschungsinstitut Leder und Kunststoffbahnen

CNT-CONTAINING SILICONES IN CALENDERING APPLICATIONS FOR HIGHLY CONDUCTIVE FUNCTIONAL LAYERS

The flexible, electro conductive polymer films with high heating power are highly suitable as heatable composite materials for vehicle interiors. They can either be applied to the interior covering of a vehicle or built directly into the driver's seat as a functional layer. When a defined voltage is applied, a certain temperature change can be achieved. With a suitable material design or composite fomulation, the heating temperature can be set precisely so that the heating foil is protected against overheating.

MATERIALS AND PROCESSING

Materials

For low-shear processing of MWCNTs in silicone rubber, low-molecular 2-component silicone mass, was chosen, which have a relatively low viscosity (ca. 10^4 mPas). The crosslinking reaction of polysiloxane is based on the reaction of the lateral vinyl groups of a siloxane chain of component A with hydrogen of the other siloxane chain of component B in the presence of a Pt-catalyst forms a high molecular silicone. The main advantages of polysiloxanes include high temperature resistance and flexibility.

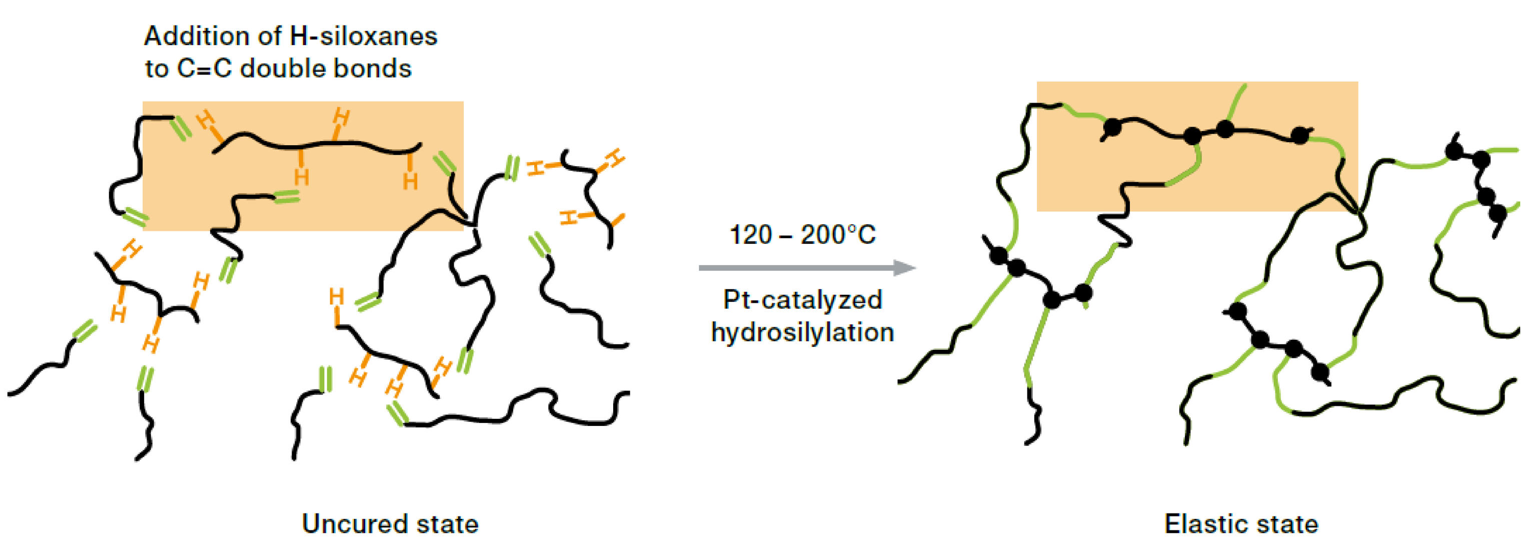

Fig 1: Addition of H-siloxanes to C=C double bonds in the presence of Pt-catalyst
(source: Wacker "Material and processing guidelines")

Processing

The incorporation of MWCNTs into the pasty, low-viscosity silicone took place on the three-roll mill (fig. 2 left side) and the subsequent shaping the foil and its curing on the three-roll calender (fig. 2 right side) First, the components were mixed at three-roll mill at low shear rates. The silicone mass was then shaped on a three-roll calender with simultaneous curing of the material between the 2nd and 3rd roll.

Fig 2: left picture - incorporation of MWCNTs in a silicone matrix on a 3-roll mill
right picture - processing of silicone MWCNT composite masses on the 3-roll calender

Processing Results

The addition of fumed silica improves the processing of CNT-containing silicone compounds. It is possible to continuously manufacture free-standing functional silicone films up to 400 µm in thickness with the help of calendering.

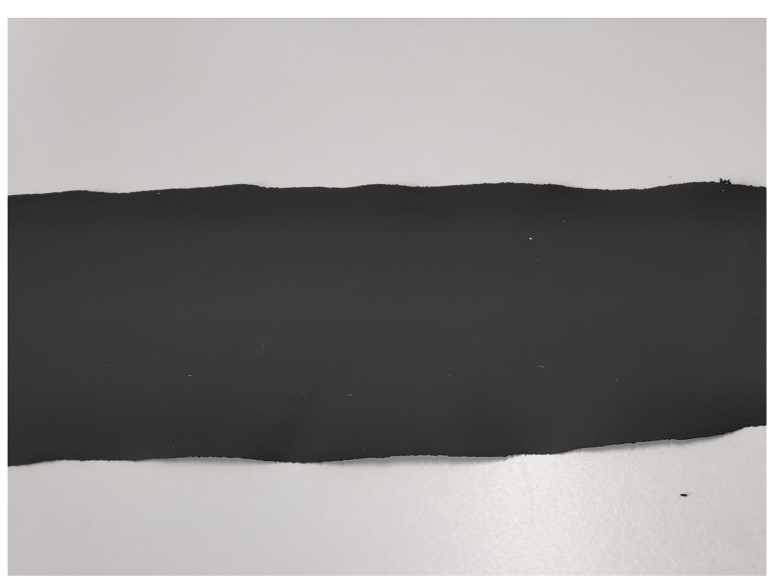

Fig 3: silicone film

CHARACTERIZATION

Measurement of resistivity

Resistivity measurement was carried out according to the 4 pin measuring method on the rectangular samples with a layer thickness of approx. 400 µm and dimensions of 50 mm x 40 mm. The measurement is carried out using a Loresta-GX MCP T-700 device. The following resistivity were determined and the conductivities calculated:

Table 1.: the results of resistivity measurements

Silicon sample	MWCNT content [%]	SiO_2 content [%]	Resistivity [Ωm]	Conductivity [S/m]
Nr. 1	5	2	1,58E-02	63
Nr. 2	5	0	1.02E-02	98

Heating Experiments

With the help of a step-by-step increase of amperage, it is possible to measure the change in temperature as a function of the voltage under mechanical stress. As can be seen in Fig. 4, the increase in voltage leads to heating of the sample. As expected, an expansion of the sample leads to a lowering of the temperature when a voltage is applied, which is due to the disruption of the percolation network.

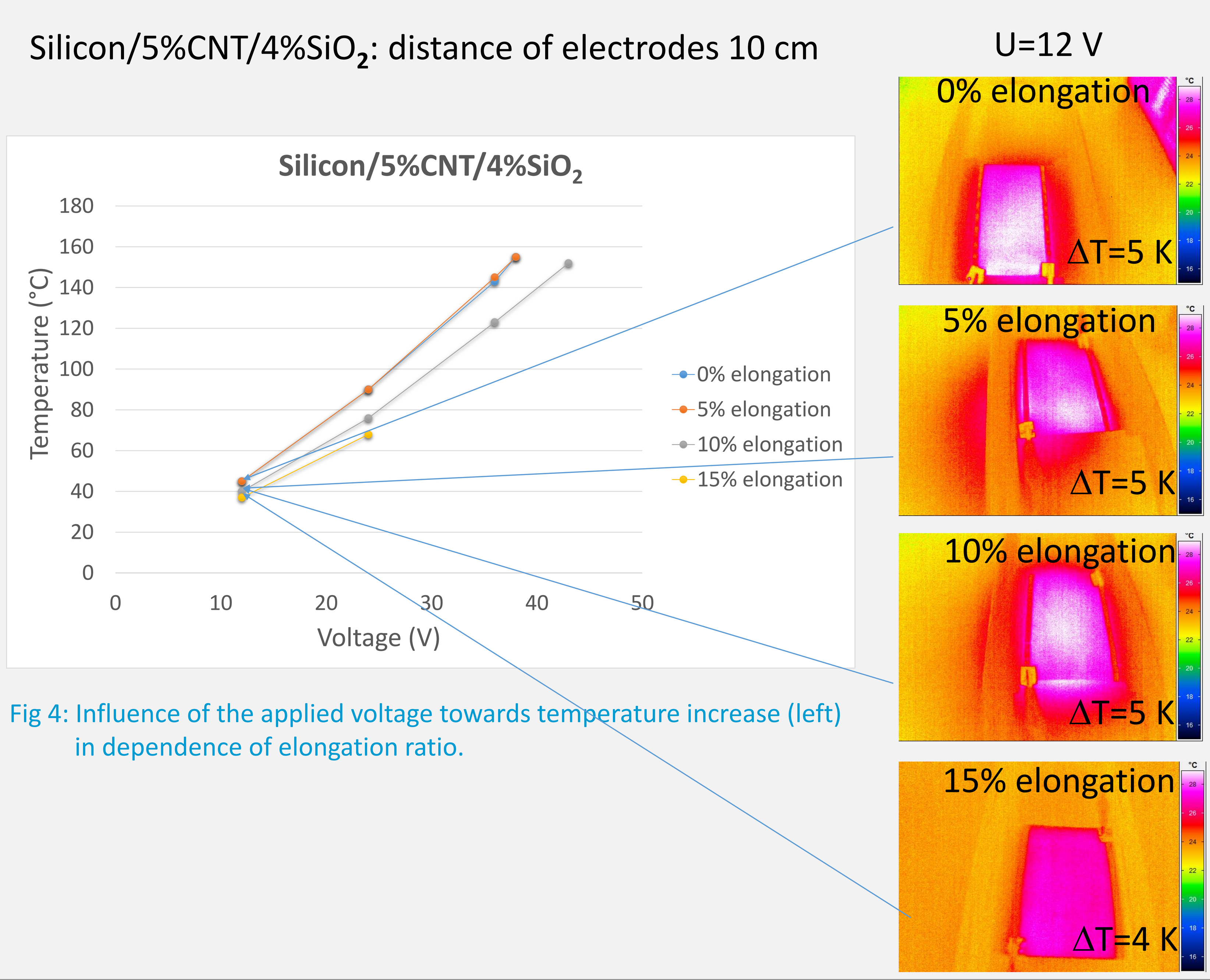

Fig 4: Influence of the applied voltage towards temperature increase (left) in dependence of elongation ratio.

Results

The processing of low-viscosity silicone masses with the aid of calendering offers low-shear incorporation of CNTs into the polymer mass for the production of electroconductive functional silicone films. Due to the lower shear stress and extension flows during calendering, the carbon nanofibers are not mechanically damaged and a peroclation network can be formed. The process can easily be implemented on an industrial scale, without further optimization steps. A continuous process enables the production of defect-free electroconductive foils with good mechanical properties.

CONTACT
Dr. Sergei Wittchen
Telephone: +49 3731 366, Email: sergei.wittchen@filkfreiberg.de
Forschungsinstitut für Leder und Kunststoffbahnen (FILK) gGmbH
Meißner Ring 1-5, 09599 Freiberg / GERMANY
www.filkfreiberg.de

Gefördert durch: Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages
INNO-KOM-Ost

Acknowledgement
The research project Reg.-Nr.: MF49MF190038 was partly funded by the Federal Ministry of Economics and Energy (BMWi) within the funding program "„FuE-Förderung gemeinnütziger externer Industrie-forschungseinrichtungen in Ostdeutschland – Modul - Marktforschung (MF)". We would like to thank for the support awarded.