A study on the state of the art of conductive silicone nanocomposites for stretchable electronics

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Introduction

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- One of the topics within the functional materials engineering group (FME) is the investigation of stretchable electronics
- Conductive nanocomposites are made with conductive particles and the silicone PDMS
- Accurate percolation thresholds of the fillers need to be determined

Preliminary study

- How can we estimate the resistivity of bulk particles?
- What is the best dispersion technique?
- What is are the reported percolation thresholds of the used particles?

Practical investigations

- Measuring the resistivity of bulk particles
- Dispersion experiments
- Percolation experiments
- Characterisation of the composite

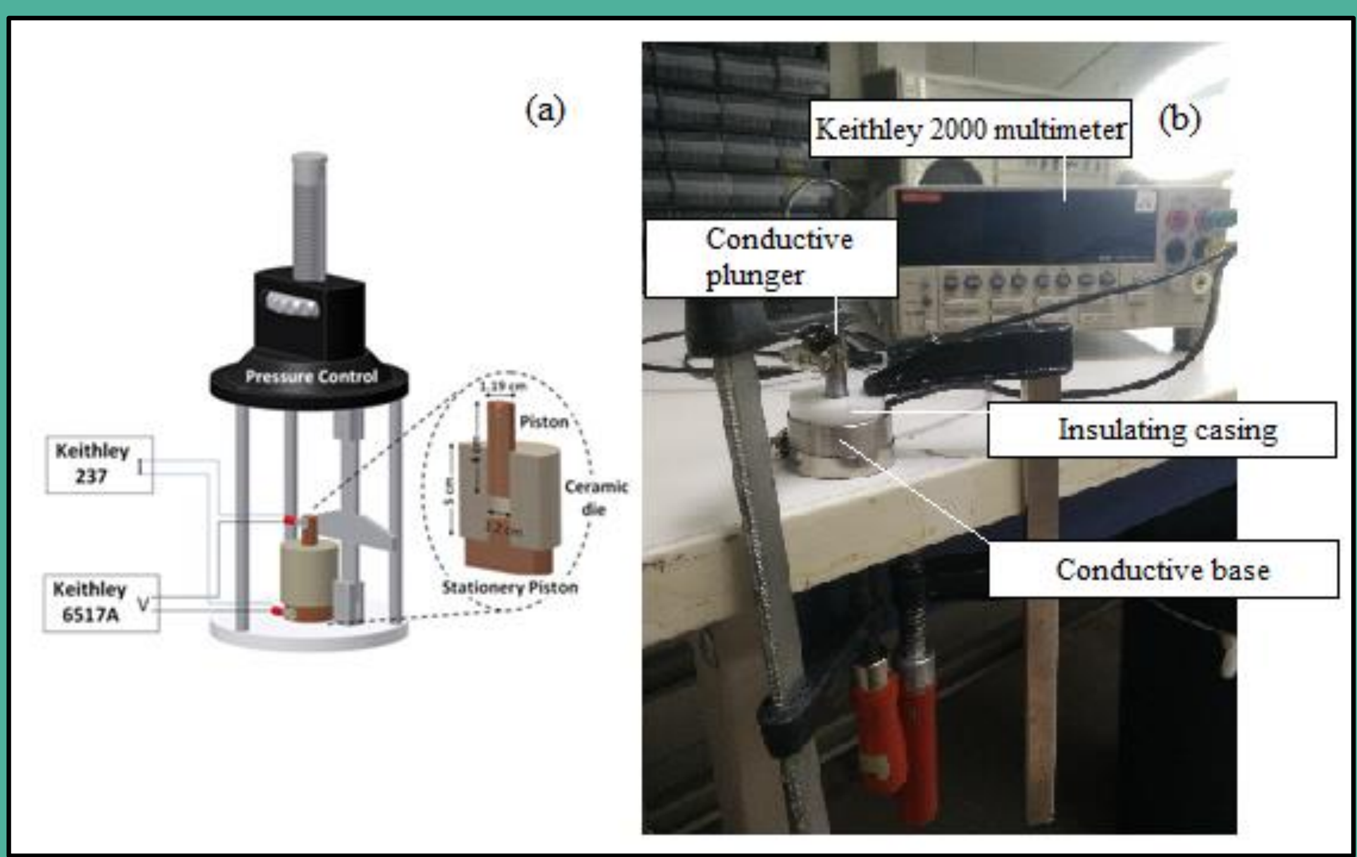
Results

- Estimation of the conductivity of the particles
- Four achieved percolation thresholds
- Gauge factor determined for each composite

Practical investigations

Resistivity of bulk particles

- A powder press compresses the particles, thus increasing the contact area
- A Keithley measures the resistance
- Bulk resistivity is calculated with of the compressed disk



Dispersion experiments

- Solution mixing, high speed mixing, ball milling and three roll milling are compared

percolation experiments

- Samples are fabricated and the resistance is measured

Characterisation

- Tensile tests determine the Gauge factor and the elongation until breakage

Results

Resistivity of bulk particles

- An estimation of the resistivity was made

Material	Calculated resistivity
Carbon black	1.95 x 10^{-2} Ω*m
Carbon black & CNTs	6.70 x 10^{-4} Ω*m
Silver coated copper flakes	3.35 x 10^{-4} Ω*m
Pristine SWCNTs	5.02 x 10^{-4} Ω*m
Silver nanowires	4.61 x 10^{-3} Ω*m

Dispersion experiments

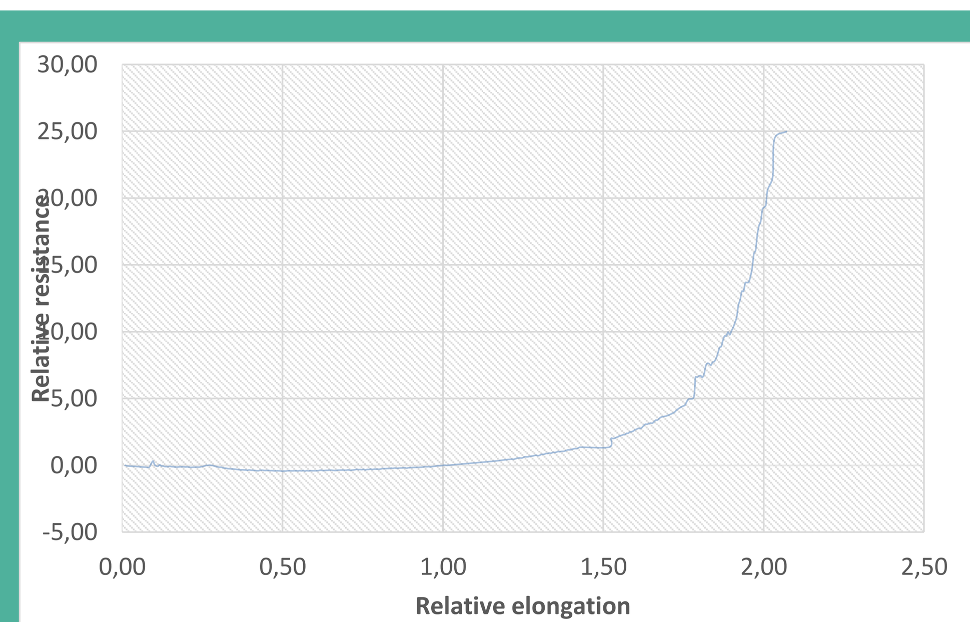
- High speed mixing and three roll milling yield the best results, based on SEM images

Percolation experiments

Filler	Volume percentage (vol%)	Weight percentage (wt%)	Resistance (Ω)
CB & CNTs	29.22	6	7.50 x 10^4
MWCNTs	5.34	9	1.32 x 10^6
SWCNTs in PDMS oil (Matrix)	0.09	0.10	2.24 x 10^7
Pristine SWCNTs	Incalculable (unknown pristine SWCNT density)	0.10	2.23 x 10^7

Characterisation

- Composites containing carbon black exhibit a high chance in resistance under strain
- On the other hand, the resistance of MWCNT composites remains constant until an elongation of 100%, as depicted on the right



Conclusions

- The resistivity of the bulk powders was estimated
- Four percolation thresholds are accurately determined
- Conductive composites were created which exhibit favorable characteristics for both stretchable strain sensors as conductors, depending on the filler

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