Study of the impact of high-voltage trimming on several characteristics of model TFRs and their stability

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Voltage Trimming
High-voltage pulses induce changes in the microstructure of the thick-film resistor (TFR), usually increasing their conductivity, but increasing their sensitivity to temperature. As shown here exposition to 250°C can lead to a further increase of the conductivity as large as 20%.

Thick-film resistors
TFRs are disordered conductor-insulator compounds. They display a conductor-insulator transition at a critical volume concentration $X_C$. The relative change of conductivity due to voltage pulses has a divergence as $X_C$ is approached.

Thermal coefficient of resistance
The thermal coefficient of resistance (TCR) is shifted upwards by the voltage-trimming step in all our samples. Contrary to what is observed with the conductance, the TCR shift is maximal for samples in the mid range of concentrations studied in those experiments. We also notice that thermal treatment tends to shift the TCR back towards its original value (before trimming). This is again the opposite of what we observed for the conductivity of the samples.

Piezoresistivity and Voltage-Trimming
The piezoresistivity is also modified by high-voltage trimming. As shown here the shift of piezoresistivity displays a divergence close to the percolation threshold $X_C$, just like the conductivity does. This can be understood considering that the global change in conductivity and piezoresistivity is induced by changes in the local conductances between neighboring conducting particles. The conductivity of such bonds is increased by strong local heating, which happens mostly in bonds with large resistance and carrying the full current running through the sample. As there are more such bonds close to the percolations threshold, this explains the increased sensitivity to trimming close to the percolation threshold.

Change of DC critical exponent
The explanation of the phenomena inducing conductivity and piezoresistivity changes suggest that trimming basically changes the distribution function of local conductances $h(g)$, by increasing the low conductivities. It is well known that the conductivity of percolating compounds such as TFRs follows a power law of the form

$$\Sigma = \Sigma_0 (X - X_C)^t$$

With critical exponent $t$, being greater than 2 (nonuniversal) only if $h(g)$ has a strong divergence for small conductances. Therefore trimming should drag $t$ towards its universal value, as observed here.