Should you put a ring on it? Or should you get sticky with it? Comparing electrical homogeneity in nanoring and nanostick networks

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Transparent conductive electrodes (TCEs) are essential materials for a wide range of next generation electronic and optoelectronic devices such as touch panels, displays and solar cells [1]. The most commonly used TCEs are based on indium tin oxide (ITO), which is not only rare, expensive and not eco-friendly to extract, but also extremely brittle, making it unsuitable for flexible devices. Therefore, there is a strong demand for alternative TCEs that are not only transparent and conductive, but also flexible and low-cost. Networks of metallic nanowires (NWs) are considered as one of the most promising alternatives to ITO.

While most of the scientific literature focusses on straight NWs (so-called nanorods), nanowires can also be manufactured in a circular shape (so-called nanorings) [2]. Due to their different geometry, nanorings have no dead ends in the percolation network. This could not only result in improved conductive properties but also reduce the occurrence of hotspots, leading to more durable electrodes [3].

Electrical homogeneity quantifies the homogeneity of the power distribution throughout the nanowire network. Networks that have a low electrical homogeneity (i.e. have problematic hotspots) result in electrodes that quicky breakdown under electrical stress. This is because regions with a peak in power density values lead to degradation of wires as a result of Joule heating and electromigration. This results in a snowball effect that destroys other wires and eventually the whole network breaks down. In this work, we propose a method (Figure 1) to calculate the electrical homogeneity and we investigate the effect of multiple design parameters of the network on the electrical homogeneity.

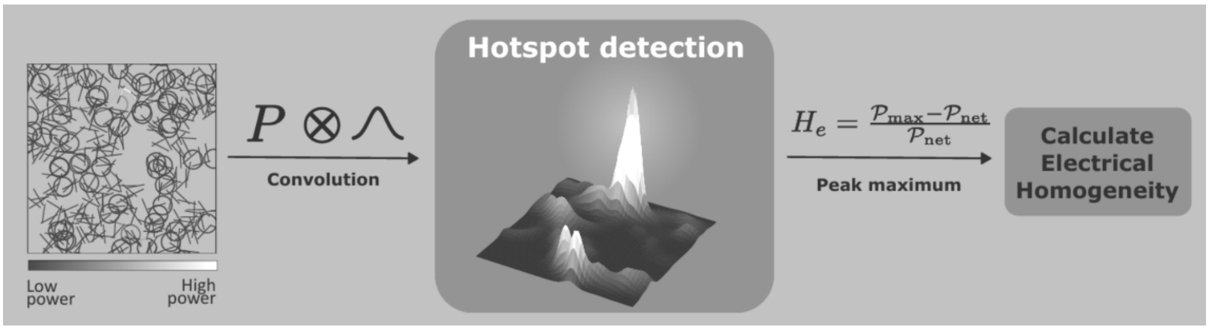

Figure 1: Strategy to calculate the electrical homogeneity. In the left image, we see a few wires that have a high power value. Using the convolution method, we are able to detect these hotspots (center image). The result of this convolution operation (and it's corresponding power density) is used to calculate the electrical homogeneity measure.

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