Electrical stress on metallic nanoring based networks for flexible transparent electrodes

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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 hot spots, leading to more durable electrodes [3].

In this work, we investigate the durability of an in silico network of nanorings (like in figure 1) by subjecting them to electrical stress, which seems to be one of the most important factors influencing their durability. The model for electrical stress is simple yet effective, as it is able to reproduce the main response features of an experimental sample under electrical stress. We also compare our results with those of a network of straight nanorods from [4], who used the same stress model. Compared to the nanorod networks presented in that study, we found nanoring networks that were better able to withstand the electrical stress.

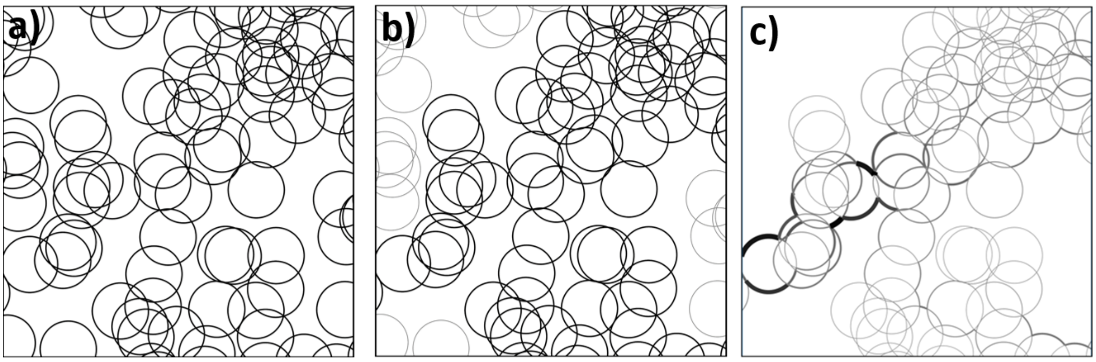

Figure 1: An example of a nanoring network a) and its percolating cluster b). A voltage difference is placed between the vertical terminals, which results in current flowing through the percolating cluster. These currents are illustrated in c), where thicker and darker lines indicate a higher current.

[1] Kumar *et al* 2022 *Mater. Today Commun.* **33** 104433
[2] Li Z *et al* 2020 *Micromachines* **11** 236
[3] Azani M and Hassanpour A 2018 *Chem. Eur. J.* **24** 19195
[4] Grazioli D *et al* 2024 *J. Compos. Sci.* **245** 110304