3DStrong TECHNOLOGY

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Carbon nanotubes-Metal Oxide Nanowire networks for Energy-Efficient Buildings

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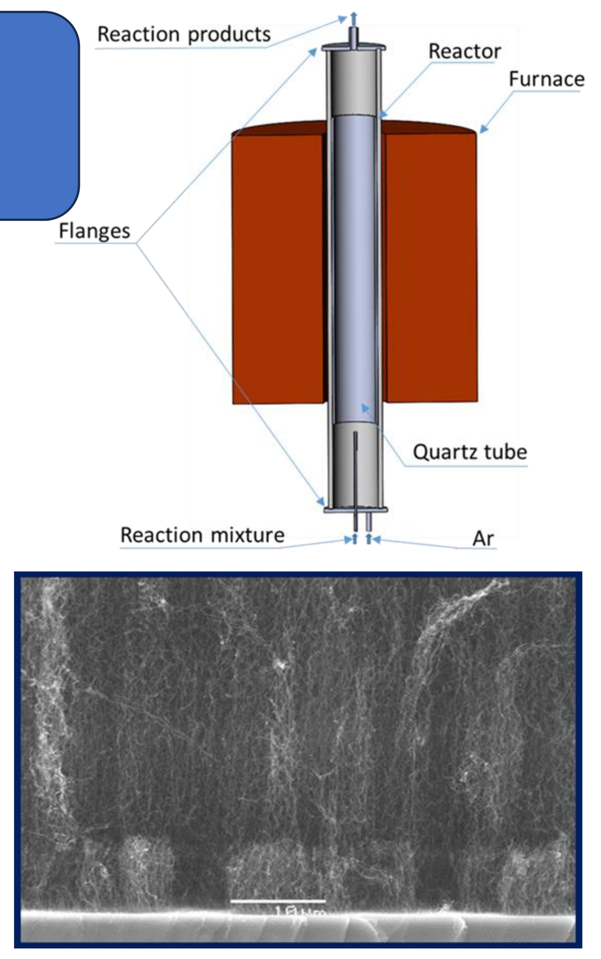
Introduction

Buildings in the EU are the biggest energy consumers, responsible for 40% of energy usage and 36% of CO_2 emissions. To cut energy consumption by up to 50 %, thermal insulation is commonly used. To go further, in this work we propose incorporating thermoelectric modules in insulation panels to generate electricity from a temperature gradient of 10-30 °C, resulting in an additional 10% reduction in power consumption. Metal oxides like copper oxide are cost-effective and eco-friendly for near-room temperature thermoelectric applications. However, their low electrical conductivity limits commercial use despite having a relatively high Seebeck coefficient.

CNTs offer a solution by enhancing electrical conductance without significantly affecting the Seebeck coefficient. This study focuses on producing carbon nanotubes-copper oxide nanowire networks using various methods, such as chemical vapor deposition, annealing, thermal vacuum deposition, and thermal oxidation techniques [1]. Electron microscopy and thermoelectrical measurements were used to characterize the networks.

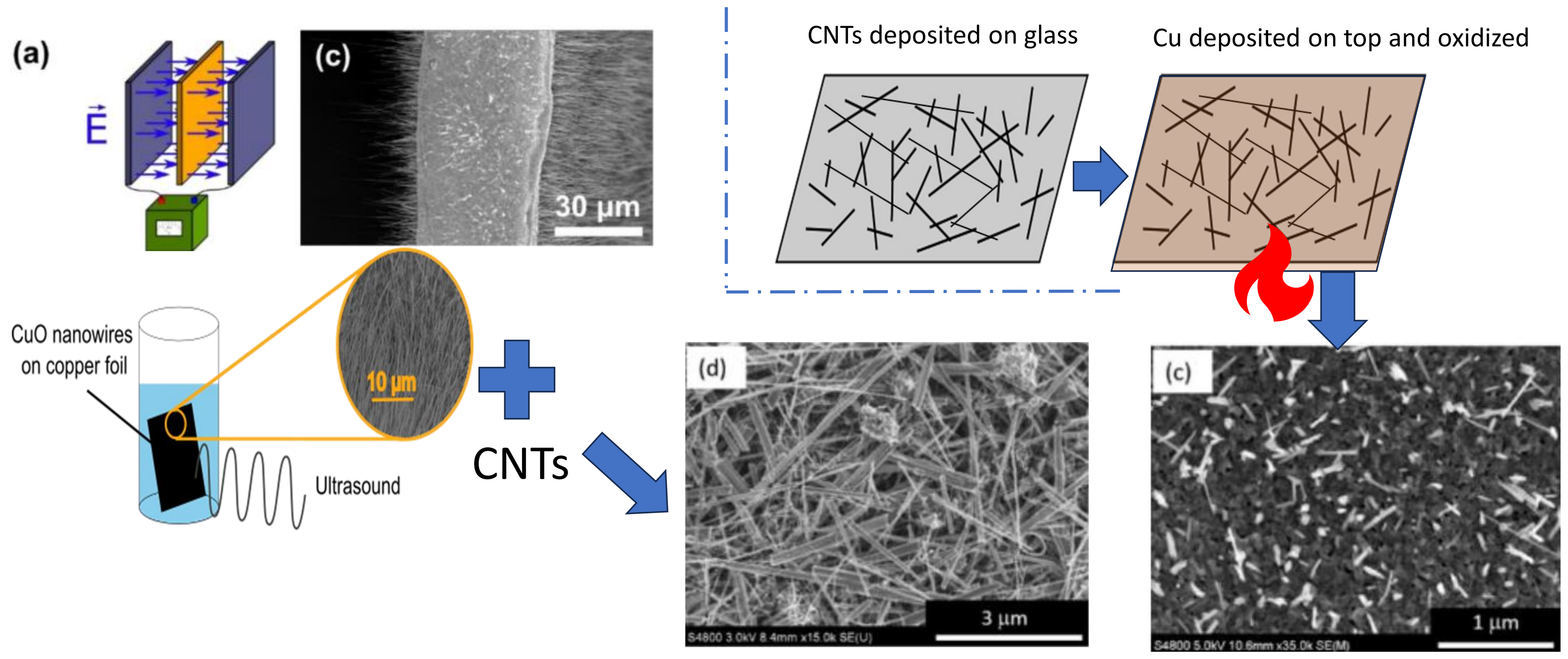
Fabrication

MWCNTs were synthesized using the spray-assisted chemical vapour deposition method. The reaction mixture must be delivered into the synthesis zone in the form of aerosol by a dispenser [2].



Mixed CuO-MWCNT networks

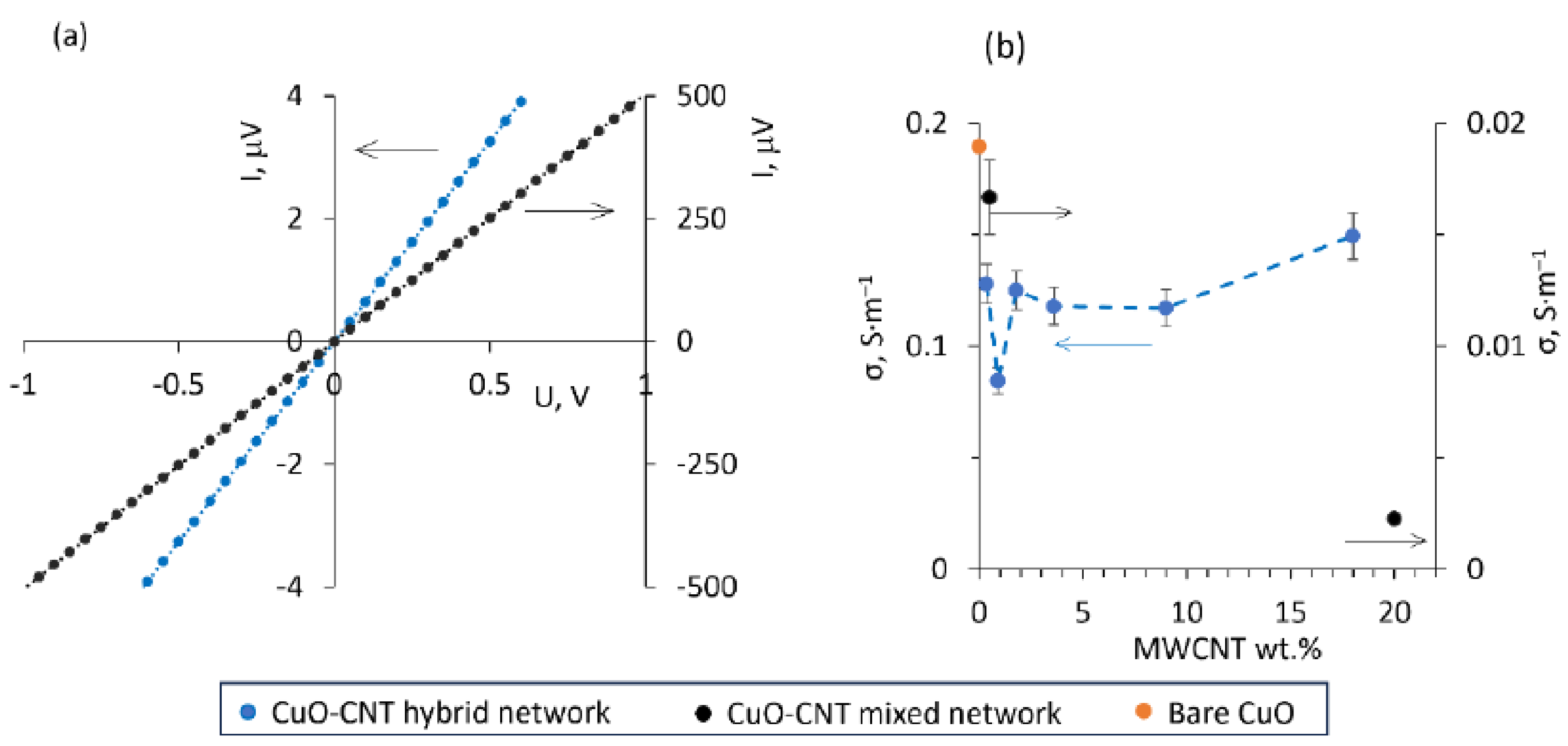
Hybrid CuO-MWCNT nanostructured composites



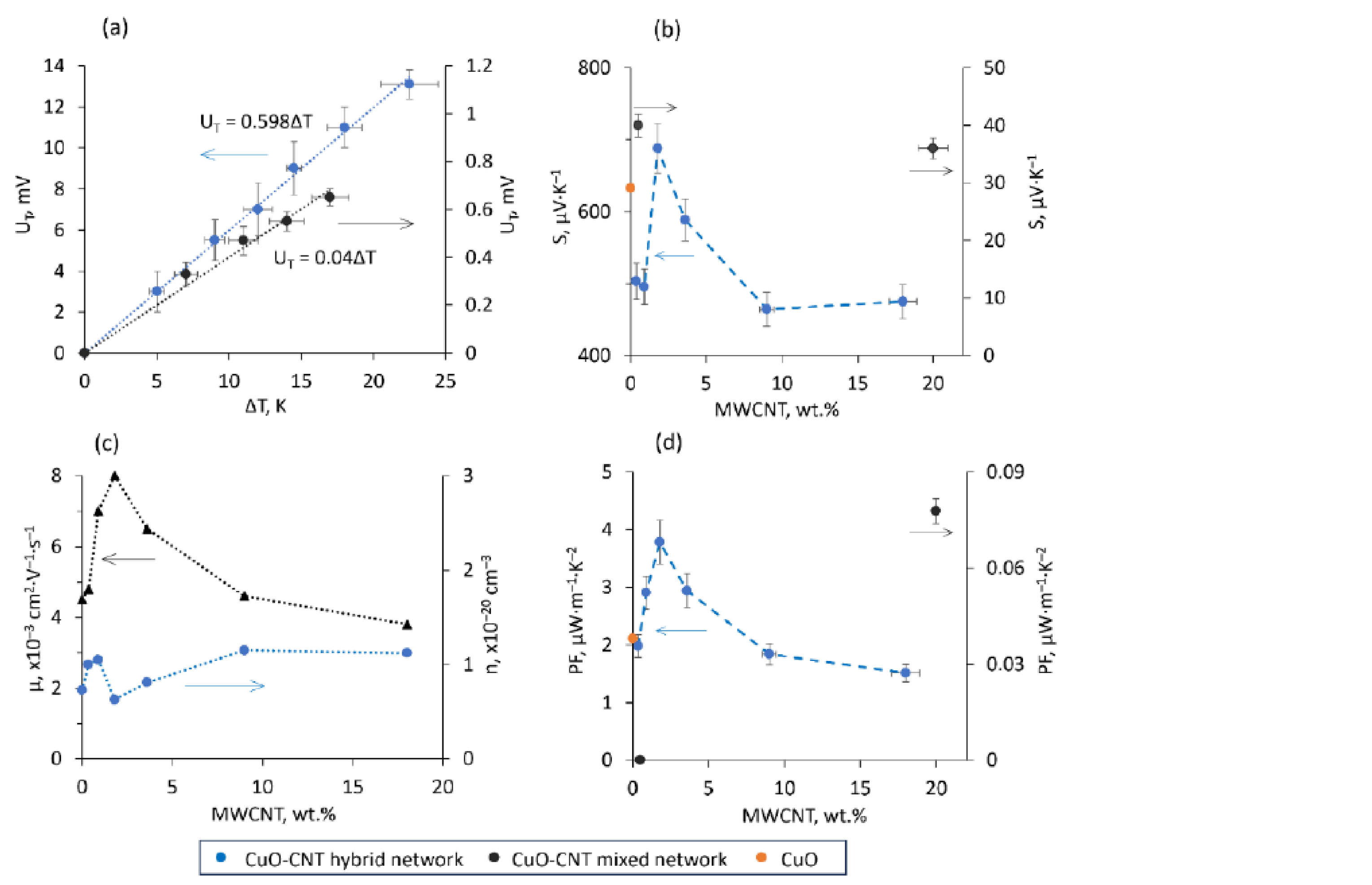
Results

$$\mu = \frac{\sigma}{ne}$$

$$S = \frac{8\pi^2 k_B^2 T}{3eh^2} m^* \left(\frac{\pi}{3n}\right)^{\frac{2}{3}}$$



(a) representative current-voltage curves of CuO-MWCNT hybrid composite with ~ 2 wt.% of MWCNTs (blue dots, primary axis) and CuO-MWCNT mixed network with 0.5 wt.% of MWCNTs (black dots, secondary axis); (b) electrical conductivity of bare CuO layer (orange dot), CuO-MWCNT hybrid composites (blue dots), and CuO-MWCNT mixed networks (black dots, secondary axis) vs MWCNT wt.% in the network.



(a) thermally generated voltage UT vs. temperature difference applied between the sides of the CuO-MWCNT hybrid composite (3.6 wt.% of MWCNTs, blue dots, primary axis), and CuO-MWCNT mixed network (0.5 wt.% of MWCNTs, black dots, secondary axis); (b) Seebeck coefficient of bare CuO layer (orange dot), CuO-MWCNT hybrid composites (blue dots), and CuO-MWCNT mixed networks (black dots, secondary axis) vs. MWCNT wt.% in the network; (c) mobility (black triangles, primary axis) and charge carrier concentration (blue circles, secondary axis) of the CuO-MWCNT hybrid composites vs MWCNT wt.% in the network; (d) power factor of bare CuO layer (orange dot), CuO-MWCNT hybrid composites (blue dots), and CuO-MWCNT mixed networks (black dots, secondary axis) vs MWCNT wt.% in the network.

Summary

Novel method for fabrication of CuO-MWCNT hybrid composites

- CuO the main contributor to the Seebeck coefficient
- MWCNTs the main contributor to the electrical conductance, leading to the increase of the power factor by 2 and ~ 5-50 times compared to bare CuO and mixed CuO-MWCNT networks, respectively

CuO-MWCNT hybrid nanostructured composites room-temperature thermoelectric PF of ~ 4 ⍰W·m^{-1}·K^{-2} was by an order of magnitude higher compared to that of recently reported $[CuO]_{99.9}[SWCNT]_{0.1}$ composites, and comparable with the recently reported PF for Sb_2Te_3-MWCNT hybrid networks, while using ~ 3 times less of MWCNTs

References

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Acknowledgments

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