Take nanofabrication easy: electrodeposition of energy-related materials

Mikołaj Kozak*[1,2], Agnieszka Brzózka[1], Leszek Zaraska[1]
[1]Faculty of Chemistry, Jagiellonian University, Poland
[2]Doctoral School of Exact and Natural Sciences, Jagiellonian University, Poland
mikolaj.kozak@doctoral.uj.edu.pl

INTRODUCTION

Electrodeposition allows to obtain many materials and control their morphology by changing synthesis parameters or using templates. This versatility, as well as its repeatability, scalability, and relatively low cost, makes this techique very useful for synthesizing many nanomaterials with promising properties and many applications[1].
Here we present novel materials for electro- and photoelectrochemical water splitting and supercapacitors prepared by direct electrodeposition or in a two-step electrochemical-thermal approach.

EXPERIMENTAL

Direct electrodeposition was used for the preparation of cobalt selenide and iron selenide thin films, and also for template-assisted synthesis of Cu_2O nanowire arrays. Selenides were deposited from deep eutectic solvents – a class of non-aqueous media that prevent the formation of oxides and hydroxides and offer a wide potential window, which is very important during the simultaneous reduction of two species. Cu_2O nanowire arrays were synthesized by electrodeposition inside channels of anodic aluminum oxide (AAO) from alkaline aqueous solution.
Combined, the electrochemical-thermal technique was applied to obtain tin oxide nanowire arrays. In the first step, Sn nanowires were deposited into channels of the AAO template. As-prepared metallic nanowires were then annealed in air to convert them into tin oxide. The combined technique was also used as an alternative way of preparing cobalt selenide thin films. In the first step, cobalt was electrodeposited on graphite from aqueous solution, and in the second step, selenized in a tube furnace, in selenium vapors.

RESULTS AND DISCUSSION

Electrodeposition from deep eutectic solvents allowed the obtaining of amorphous thin selenide films. Iron selenide was tested as an electrocatalyst for hydrogen evolution, while cobalt selenide was tested as an electrode material for supercapacitors. Cobalt selenide thin films, fabricated via a two-step technique, were crystalline, thanks to the high temperature of the process[2]. Semiconductive nanowires – tin oxide and cuprous oxide were tested as electrode material for photoelectrochemical water splitting.

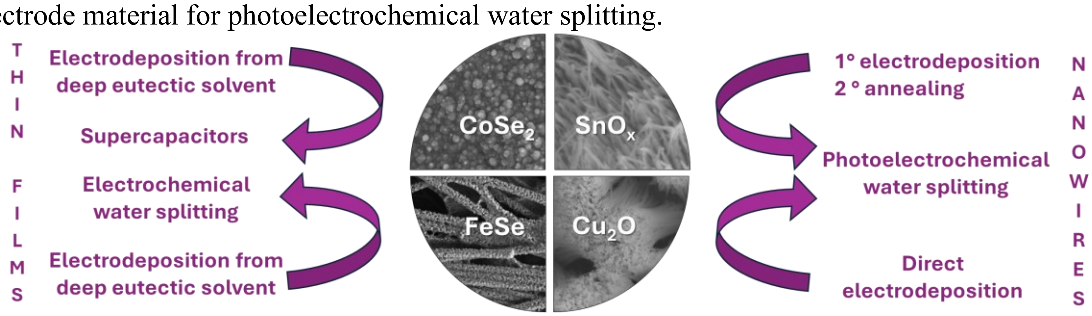

Fig. 1 Graphical abstract

CONCLUSION

The multitude of fabrication techniques based on electrodeposition enabled the synthesis of conductive and semiconductive nanomaterials in the form of thin films and nanowires. This synthetic approach, due to its versatility, opens the way for the preparation of a wide range of materials.

REFERENCES

1. I. W. Sun, J. K. Chang, Springer Handbook of Electrochemical Energy 2017, 835-895
2. M. Kozak, et al. Applied Surface Science 2025, 686: 162070.

ACKNOWLEDGMENTS

The research was financially supported by the National Science Centre, Poland (Projects No. 2017/26/M/ST5/00715 and 2018/30/E/ST5/00531) and Anthropocene PRA under the strategic programme Excellence Initiative at the Jagiellonian University.