ASEC 2024 Conference

The 5th International Electronic Conference on Applied Sciences

04–06 December 2024 | Online

MDPI

Morphological and sensing properties of electrochemically deposited ZrO_2 layers

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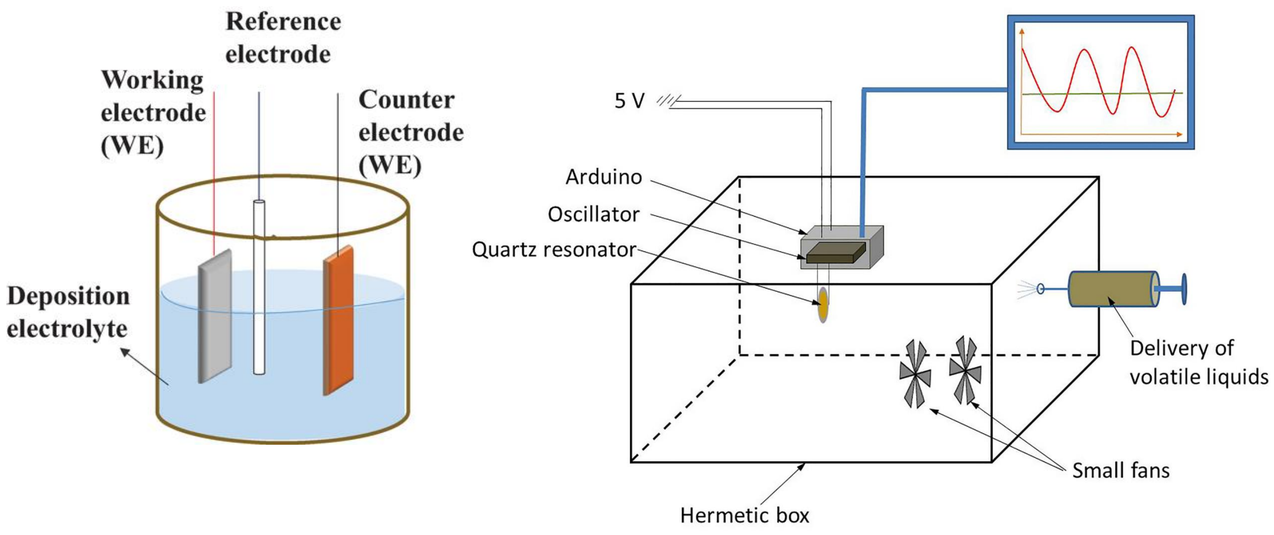
INTRODUCTION & AIM

Due to its unique properties like high mechanical and thermal resistances, high dielectric constant and refractive index, wide range of optical transparency and capability for diverse nanostructuring, ZrO_2 is increasingly relevant material with applications in different fields such as optoelectronics, medicine and gas sensing. Here, nanostructured films of ZrO_2 were deposited by electrochemical method on the gold electrodes of AT-cut quartz resonators.

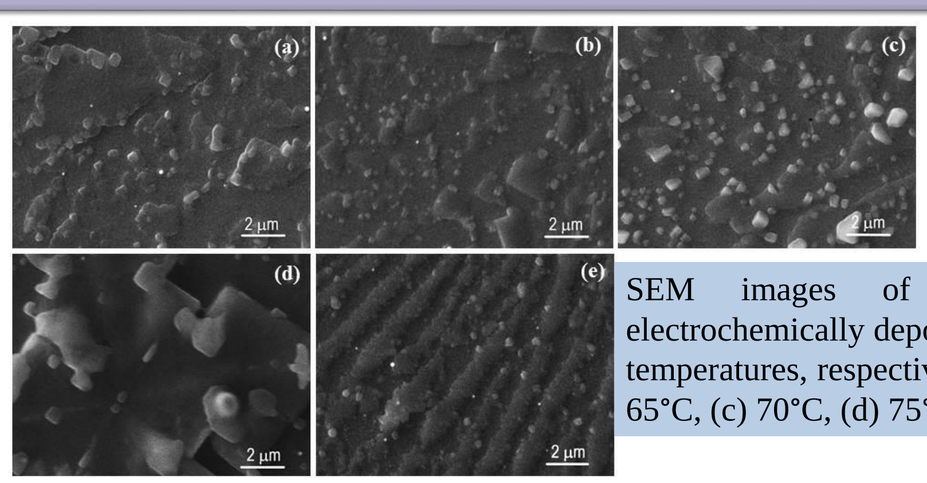
METHOD

- The proposed electrochemical deposition method is cost-effective, environmentally compatible, requires relatively simple apparatus and offers easy control of morphology and stoichiometry of the produced nanostructures by varying the deposition parameters.
- The deposition of ZrO_2 electrochemical layers was carried out in an aqueous solution containing 5 mM of $ZrOCl_2$ and 100 mM of KCl.
- To study the layers' sensing abilities towards ammonia and ethanol vapors Quartz Crystal Microbalance (QCM) method was applied.
- Scanning Electron Microscopy (SEM) was used to investigate the influence of the electrodeposition conditions (temperature and time) on the layers' morphology.

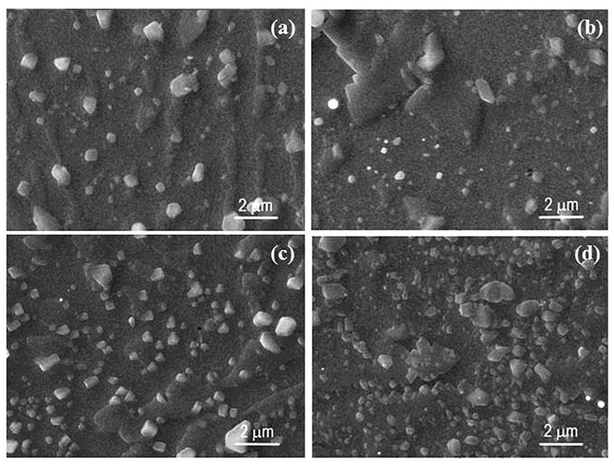


Three electrode electrochemical cell (left) and experimental setup for gas sensing measurements (right).

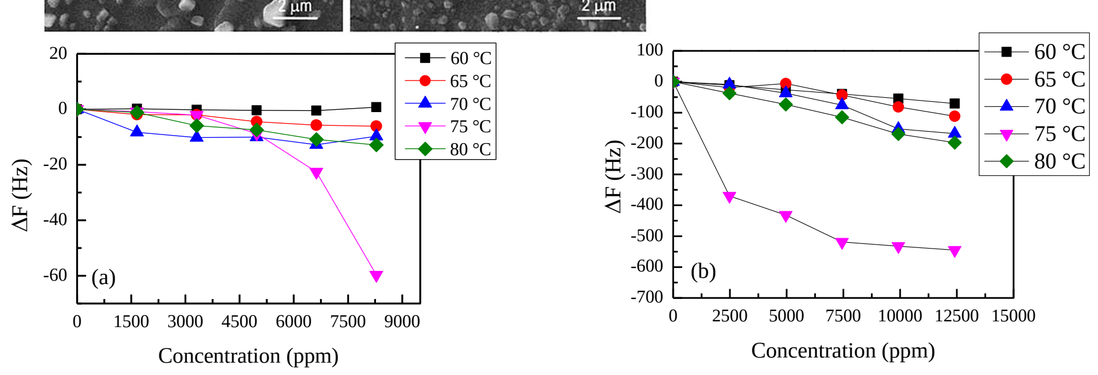
RESULTS & DISCUSSION



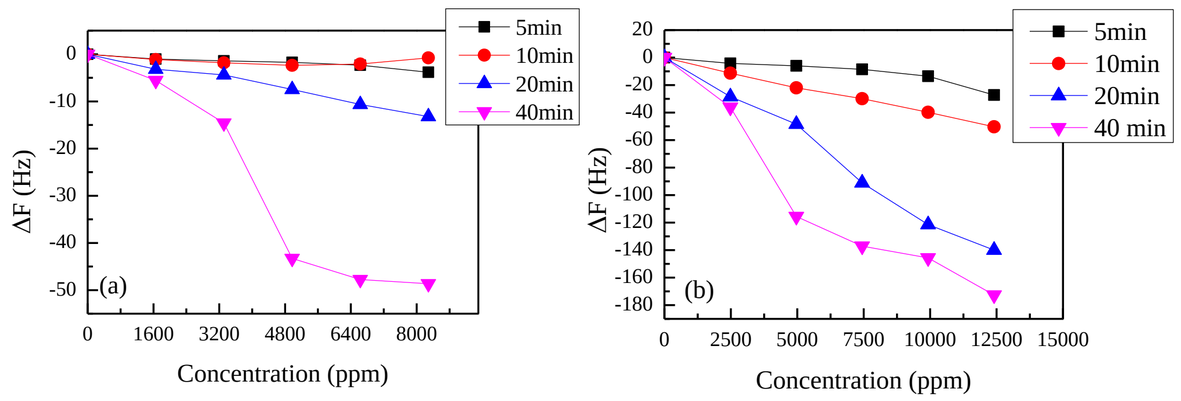
SEM images of ZrO_2 layers, electrochemically deposited at different temperatures, respectively (a) 60°C, (b) 65°C, (c) 70°C, (d) 75°C and (e) 80°C.



SEM images of ZrO_2 layers, electrochemically deposited at different deposition times, respectively (a) 5 min, (b) 10 min, (c) 20 min and (d) 40 min.



Sensitivity results for electrochemically deposited ZrO_2 layers to ethanol (left) and ammonia (right) vapors at different deposition temperatures.



Sensitivity results for electrochemically deposited ZrO_2 layers to ethanol (left) and ammonia (right) vapors at different deposition times.

CONCLUSION

- The size, shape and density of the grains that are located on the surface of the layers significantly depend on the deposition temperature;
- The deposition time has an impact on the grain density on the surface of the layers: the density increases with increasing deposition time;
- The layers are more sensitive to ammonia and less sensitive to ethanol vapors;
- For both types of volatile compounds, larger frequency variations are measured for the layers with more developed surfaces;
- The results show essential features of zirconia electrochemical layers, important for the design and development of ZrO_2 sensing devices.

Acknowledgments: This research is funded by Bulgarian National Science Fund (BNSF) under the project КП – 06 – Н38/7 (12.2019). Research equipment of Distributed Research Infrastructure INFRAMAT, part of Bulgarian National Roadmap for Research Infrastructures, supported by Bulgarian Ministry of Education and Science was used in this investigation.