Interface-Engineered Metal Oxide–Porous Material Heterojunctions for VOC Gas Sensing Applications

BSc / MSc Thesis
HiWi Projects

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Motivation

We are a research group specializing in gas-sensing technologies through printed electronics.

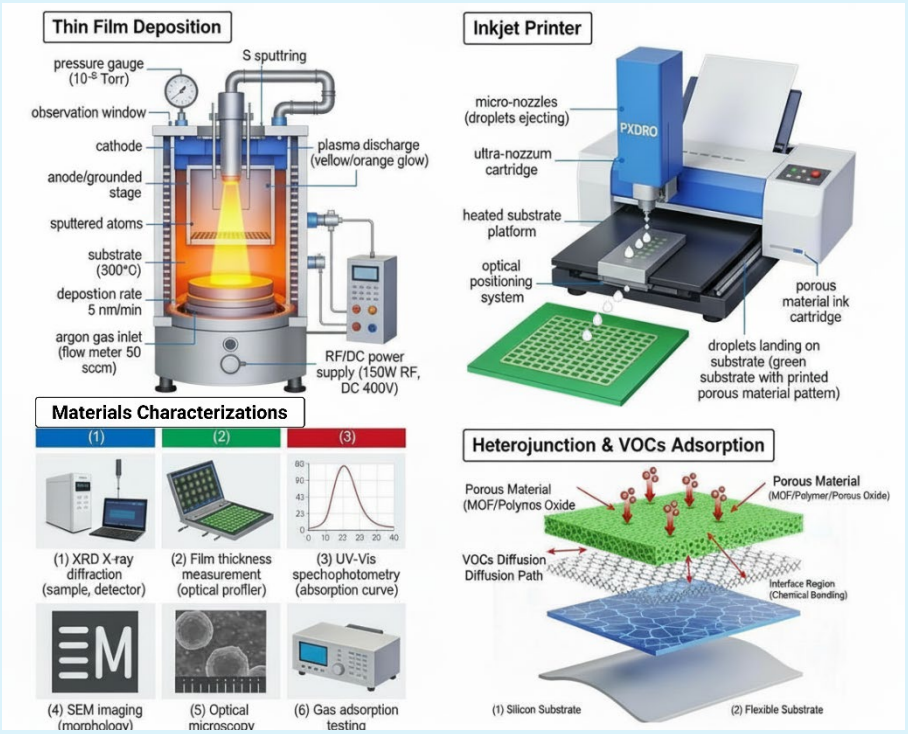
Volatile organic compounds (VOCs) pose a significant environmental and occupational health concern, necessitating reliable, cost-effective detection solutions across various applications, including indoor air quality monitoring, industrial process control, medical diagnostics, and safety systems. Current commercial VOC sensors often suffer from limited selectivity, cross-sensitivity, high power consumption, or require frequent recalibration, which limits their practical deployment.
We address this by combining metal oxides with porous materials to create heterojunctions with engineered interfaces for enhanced VOC detection. This approach bridges thin-film precision, scalable printing, and advanced characterization.

Description. We are depositing thin films of metal oxides using sputtering systems and solution-based methods, with precise control of the oxygen stoichiometry to develop phase-transition materials. These metal oxide layers are integrated with complementary porous materials to form heterojunctions for device applications. This is fundamental research aimed at practical applications in gas sensing of VOCs. The project focuses on the deposition of metal oxide thin films using sputtering and printing techniques, followed by comprehensive characterization of the materials.

This is a Master's or Bachelor's thesis project with the possibility of a student assistant (HiWi) position.

Tasks.

1) Metal oxide thin film deposition on silicon and flexible substrates using a sputtering system, followed by characterization via XRD, film thickness, and UV-Vis spectrophotometry.
2) Formulation and optimization of inkjet-printable porous material inks, followed by printing onto the prepared metal oxide films to form heterojunction devices.
3) Characterization of heterojunction devices, including thickness, surface morphology (SEM/AFM), gas adsorption properties, and VOC sensing performance.



Deliverables:

- Master's or Bachelor's thesis
- Publication-ready dataset
- Experimental protocols
- 1–2 peer-reviewed publications

Expected Outcomes.

1) Optimized Heterojunction Sensor with Benchmarked Performance
2) Quantified Effects of Materials Composition, Stoichiometry, and Interface Engineering on Gas Adsorption and Sensor Response
3) Clear dataset and comprehensive report for Master's or Bachelor's thesis, and suitable for publication and follow-up Master's/PhD research.

References. (1) Yuan, H.; Tao, J.; Li, N.; et al. "On-Chip Tailorability of Capacitive Gas Sensors Integrated with Metal–Organic Framework Films." Angew. Chem. Int. Ed. 2019, 58 (40), 14089–14094. (2) Monique Ann van der Veen. "Advancements in Inkjet Printing of Metal-and Covalent-Organic Frameworks: Process Design and Ink Optimization." ACS Applied Materials & Interfaces 17, no. 8 (2025): 11469-11494. (3) Houimi, A., Kabatas, M.A.B.M., Yilmaz, M. and Eker, Y.R., 2024. MoO 3 nanowire growth on VO2/WO3 for thermochromic applications. Physical Chemistry Chemical Physics, 26(6), pp.5548-5557.