Session of "Fokus Materialchemie" – Wednesday, **26.11.2025** 14:00
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Exsolution in photocatalysis: exploring Cu/SrTiO3 perovskite dynamics

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The use of fossil fuels and the environmental consequences that come with it are one of the big chal lenges of our time. Hydrogen fuel is often regarded as a solution for this problem. However, over 80% of globally produced H2 is produced directly form fossil sources, and less that 1 % is produced with low emission methods. One approach to sustainable H2-production is photocatalytic water splitting. Here, a charge separation is induced in a catalyst material (typically a semiconductor) through light irradiation. The resulting electrons and holes can then migrate to the surface of the material and reduce/oxidise surrounding water to H2 and O2. [1][2]

In semiconductor photocatalysis for water splitting, one important factor is to promote efficient charge separation within the catalyst after photoexcitation. This can be achieved by adding a nanoparticle co catalyst on the surface of the semiconductor, which extracts the photogenerated electrons/holes while also providing a suitable catalytic site for the desired reaction, it being the hydrogen evolution reaction (HER) or the oxygen evolution reaction (OER). [1]

Over the last decades, a new method of forming nanoparticles supported on metal oxide materials has emerged: redox exsolution. Here, the elements for the desired nanoparticles are embedded in an oxide lattice (usually a perovskite) through doping. With thermal treatment, usually under reducing conditions, oxygen vacancies are created at the surface, which leads to the diffusion and reduction of the most easily reducible metal in the lattice and the formation of nanoparticles on the surface. [3] Compared to pre-deposited nanoparticles, exsolved nanoparticles are socketed into the lattice, leading to a strong metal-oxide interaction and making the particles more resistant to agglomeration. Because of these properties, exsolution is quickly gaining interest as a method to prepare oxide-supported nanoparticles for catalysis.[4][5]

In this work, the idea of exsolution will be applied to generate a dynamic photocatalyst/co-catalyst couple based on Cu-doped SrTiO3 (STO) for HER. The thesis aims to investigate the following questions:

1. How does the exsolved catalyst/cocatalys system perform for HER in comparison to copper pho todeposited on pure STO?
2. How do Cu-content and exsolution conditions affect the photocatalytic performance?
3. Can exsolution be triggered by illumination?
4. How is the catalyst/cocatalys system affected by HER (exsolution vs. photodeposition)

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[2] I. E. A., "Global hydrogen review 2024."
[3] K. Kousi, C. Tang, I. S. Metcalfe, and D. Neagu, "Emergence and future of exsolved materials," vol. 17, no. 21, p. 2006479.
[4] J. Zhang, M.-R. Gao, and J.-L. Luo, "In Situ exsolved metal nanoparticles: A smart approach for optimization of catalysts," vol. 32, no. 13, pp. 5424–5441.
[5] A. J. Carrillo, A. López-García, B. Delgado-Galicia, and J. M. Serra, "New trends in nanoparticle exsolution," vol. 60, no. 62, pp. 7987–8007.