

CatLab Lecture Series hosted by FHI and HZB

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**Friday, February 23<sup>rd</sup> 2024, 10:30-12:00**

BESSY II, Seminar Room at the Entrance, Albert-Einstein-Straße 15, Berlin Adlershof

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## Roel van de Krol

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### **Recent insights on the generation, transport, and separation of charge carriers in metal oxide photocatalysts**

Metal oxide photoelectrodes tend to be cheap, easy to fabricate, and show relatively good (photo)chemical stability in aqueous solutions. This makes them attractive candidates as light absorbers in a variety of photoelectrochemical and photocatalytic applications. However, the energy conversion efficiencies of these absorbers are poor compared to photovoltaic-grade materials.

In this lecture, I will discuss three main loss mechanisms in metal oxide-based absorbers: a sub-optimal photogeneration yield due to localized d-d transitions, inefficient extraction of the photogenerated carriers at the interface(s), and localization of carriers at defects. After reviewing the role of the electric field in charge separation, which is still often misunderstood in the fields of photocatalysis and photoelectrochemistry [1], two techniques to quantify carrier generation and transport in photoabsorbers will be discussed. One is time-resolved microwave conductivity (TRMC), a contact-free technique that can be used to determine the carrier mobility and life time. We recently developed an approach to directly determine the carrier diffusion length with this technique, without needing to deconvolute changes in the carrier concentration and the mobility [2]. The second technique I will discuss is time-resolved THz spectroscopy (TRTS), which we recently used to reveal nm-scale carrier localization in a range of oxide absorbers [3]. Throughout the presentation, I will attempt to show how these insights can be used to design more efficient metal oxide-based photoelectrodes.

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#### References

- [1] M. Schleuning, I.Y. Ahmet, R. van de Krol, M.M. May, *Sust. Energy Fuels* 6, 3701 (2022).
- [2] M. Schleuning, M. Kölbach, F.F. Abdi, K. Schwarzburg, M. Stolterfoht, R. Eichberger, R. van de Krol, F. Friedrich, H. Hempel, *PRX Energy* 1(2), 023008 (2022).
- [3] Schleuning, M.; Kölbach, M.; Ahmet, I.; Präg, R.; Gottesman, R.; Gunder, R.; Zhang, M.Y.; Wargulski, D.R.; Abou-Ras, D.; Grave, D.A.; Abdi, F.F.; van de Krol, R.; Schwarzburg, K.; Eichberger, R.; Friedrich, D.; Hempel, H. *Adv. Funct. Mater.* 33, 2300065 (2023).