# Clean Circles Mini-symposium (hybrid)

**Topic** Beyond iron as metal fuel –
Experiments and simulation of aluminum and magnesium combustion

**Date** July 11th, 2023, 10:00 - 12:15 (CEST)

**Place** Technical University of Darmstadt (TUDa)
Building L1|01, Room K284 (Institute STFS, Hasse)
Otto-Berndt-Straße 2
64287 Darmstadt

**Zoom** https://tu-darmstadt.zoom.us/j/66289424749?pwd=Tyt2cXRSU08vUkdLeS9tUWgzSmtidz09

| 11.07.2023 | | | |
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| 10:00 | 10:15 | Welcome & Introduction | Profs. Andreas Dreizler & Christian Hasse<br>*Spokespersons of Clean Circles*<br>*Technical University of Darmstadt* |
| 10:15 | 11:00 | Aluminum and magnesium as future zero-carbon energy carriers | Prof. Fabien Halter<br>*Institut des Combustion Aérothermique Réactivité et Environnement, University of Orléans* |
| 11:00 | 11:15 | Questions & Discussion | |
| 11:15 | 12:00 | Modelling of aluminum combustion in air | Dr. Fabian Sewerin<br>*Emmy Noether Junior Research Group Leader*<br>*Otto-von-Guericke-Universität Magdeburg* |
| 12:00 | 12:15 | Questions & Discussion | |
| 12:15 | | End of Minisymposium | |

## Short Abstracts

**Aluminum and magnesium as future zero-carbon energy carriers**: What if small metal particles were the future of energy? Combustion of these metal particles releases a large amount of energy and has the advantage of not emitting carbon dioxide. The combustion of these particles produces metal oxides which can then be regenerated using wind or solar energy. This cycle energy production / recycling can make it possible to store energy produced with renewable energy in a secure and sustainable way, so that it can be used where and when it is needed. This presentation illustrates the work undergone in Orléans on this original and promising concept. This work is part of a disruptive technology to solve the problem of global warming in the long term.

**Modelling of aluminum combustion in air:** While aluminum has long been used as an energetic material, it may also serve as a recyclable, carbon-neutral energy carrier, permitting energy demands to be uncoupled from intermittent green energy sources. Within the scope of the aluminum fuel cycle, aluminum powders are burnt exothermally in air and converted into oxide particles that could, at least in principle, be captured and, subsequently, recharged by reduction. A particular concern on the combustion side is the formation of nanometric oxide smoke fines which may either deposit on the burning particles or leave the reactor as an aerosol leakage. In this seminar, we present two complementary population balance-based modelling approaches that target a description of aluminum combustion on the level of a single particle or a laminar dust flame, respectively, and conclude with an outlook towards turbulent dust flames. Considering a single, spatially resolved aluminum particle, our focus lies on the prediction of the oxide smoke size distribution and an identification of the chemical and physical mechanisms by which the oxide smoke droplets grow, dissociate or deposit. In particular, the influence of smoke condensation on the shape and temperature of the envelope flame surrounding a burning aluminum particle will be assessed. Subsequently, we turn to a fully Eulerian approach for modelling laminar dust flames and show a first validation based on laminar flame speed measurements. Here, the change in particle size distribution through the flame will be quantified alongside oxide smoke and nitrogen oxide emissions. Finally, we address LES formulations of turbulent dust flames and outline a probabilistic approach for accommodating the interactions of turbulence, chemical reactions, and dispersed particles.

## Speakers

**Prof. Fabien Halter:** After obtaining a PhD in Mechanical Engineering in 2005, he worked on combustion phenomena in IC engines. He obtained a professor position at University of Orléans in 2014. There he developed canonical set-ups to experimentally investigate gaseous and multiphasic combustion processes. He is active for 10 years in the research of new energy carriers, such as metal fuels. He has co-authored more than 100 papers and has advised more than 20 PhD students. He is a member of the Editorial Board for Combustion and Flame and was awarded as Fellow of the Combustion Institute in 2022. He is the head of a Research Federation focused on energy and of the Energetics Department at University of Orléans. He has led several national and international projects in the field.

**Dr. Fabian Sewerin:**
2006 -- 2013: Diploma on Aerospace Engineering, Technical University of Munich
2010 -- 2011: MSc in Solid Mechanics, University of California, Berkeley
2013 -- 2017: PhD at Imperial College London, Division of Thermofluids, Imperial College London
2017 -- 2020: Lecturer, Institute of Solid Mechanics, TU Braunschweig
2021 -- Present: Emmy Noether Junior Research Group Leader, Otto-von-Guericke University Magdeburg