

UNIVERSITY OF CALIFORNIA, IRVINE

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

IS PROUD TO HOST A SEMINAR BY

***“BASIC MATERIALS SCIENCE ASPECTS IN
SUSTAINABLE METALLURGY”***



DIERK RAABE

**MANAGING DIRECTOR
MAX PLANCK INSTITUTE FOR SUSTAINABLE
MATERIALS
DUESSELDORF, GERMANY**

Thursday, March 12, 2026

2:00 PM - 3:20 PM

McDonnell Douglas Engineering Auditorium

Abstract: The metallurgical sector is a cornerstone of modern civilization, since 5 millennia, but it is also responsible for approximately 10% of global greenhouse gas emissions (due to fossil reductants), 10% energy demand and huge amounts of waste. Further challenges lie in reclaiming strategic and expensive elements from waste streams.

The lecture goes into some of the basic materials science opportunities lurking behind these grand challenges associated with the global transition towards more sustainable metallurgy, manufacturing and energy supply. Primary mitigation strategies involve replacing fossil carbon with sustainably produced hydrogen and/or electrons as reductants and recycling. The huge scale of global metal production—2 billion tons annually—means that the efficient use of these reductants is paramount, requiring research on sparse use of hydrogen, alternative reductants, high metallization degrees and fast reduction kinetics.

We will delve into the governing mechanisms of hydrogen-based direct reduction and plasma-assisted reduction of iron oxides. The efficiency of these processes is not merely a question of thermodynamics but is governed by a complex interplay of materials phenomena. These include mass transport kinetics, Kirkendall effects, nucleation and phase transformations, chemical partitioning, and the evolution of microstructure, porosity, and damage within the oxide feedstock during reduction. Understanding how these mechanisms are influenced by external conditions—such as reductant gas mixtures (including hydrogen and ammonia), temperature, pressure, and the initial oxide chemistry—is the key to designing efficient direct reduction or plasma reactors. The talk will also show how to make new alloys directly in a single step by co-reducing mixed oxide feedstock and even toxic industry waste, material that would otherwise have to be dumped at high costs.

Further topics discussed include the question how to produce high performance alloys with high scrap fractions since a holistic strategy must also embrace the full lifecycle of metallic materials. This includes enhancing alloy recyclability, mitigating material losses through corrosion and wear, and implementing circular economy principles to reduce the demand for primary production.

The ultimate goal is to lay the scientific foundation for the sustainable production of metals and alloys at an industrial scale and affordable cost, thereby enabling a sustainable future for this essential industry.

Bio: Dierk Raabe studied music, metallurgy and metal physics (summa cum laude) at RWTH Aachen (Germany). After his doctorate 1992 (summa cum laude) and habilitation 1997 at RWTH Aachen he received a Heisenberg fellowship and worked at Carnegie Mellon University and at the High Magnetic Field Lab in Tallahassee. He joined Max Planck Society as a director in Düsseldorf at the Max Planck Institute for Iron Research (now: Max Planck Institute for Sustainable Materials) in 1999. His main research interest is Sustainable Metallurgy, i.e. to make industrial production, use and recycling of materials more sustainable, focusing on basic research with high leverage for CO₂ emission mitigation and lower energy consumption. His specific interests are in sustainable metals (specifically 'green' steel, Nickel, Aluminium, Titanium etc.), recycling-oriented material design, metal physics, interfaces, phase transformation, atom probe tomography, materials theory, hydrogen, and artificial intelligence methods in materials science. He received the Gottfried Wilhelm Leibniz Award (Highest German Science Awards) and two ERC Advanced Grants (Highest European Research Grant). He is professor at RWTH Aachen (Germany) and at KU Leuven (Belgium). He is a Doctor Honoris Causa at the Norwegian Technical University Trondheim. He is a member and Senator of the German National Science Academy Leopoldina and of the US National Academy of Engineering.

