THE MATERIALS SCIENCE AND ENGINEERING DEPARTMENT
SPRING COLLOQUIUM SERIES PRESENTS:

Morris E. Fine Lecture: Dierk Raabe

Professor

RWTCH Aachen (Germany), KU Leuven (Belgium)

Sustainability of Metals and their role in Circular Economy

This presentation is about challenges, research opportunities and suited measures targeting the improvement of the sustainability of metallic alloys. Metals have enabled technological progress over millennia and have an enduring importance in our society. They paved the path of human civilization with load-bearing and functional applications that can be used under the harshest environmental conditions, from the Bronze Age onwards. Only metallic materials encompass such diverse features as strength, hardness, workability, damage tolerance, joinability, ductility and toughness, often combined with functional properties such as corrosion resistance, thermal and electric conductivity and magnetism [1]. Today we produce and consume about 2 billion tons of metals every year, with steels alone standing for a production of currently 1.85 billion tons per year. The huge and accelerating demand for load-bearing (structural) and functional metallic alloys in key sectors such as green energy supply, infrastructures, health, durable construction, robotics, passenger safety and modern transportation is resulting in predicted production growth rates of up to 200% until 2050 [2]. Most of these materials, specifically steel, aluminium, nickel and titanium, require a lot of energy when extracted and manufactured and these processes emit large amounts of greenhouse gases and pollution. This means that the huge success of metallic products and industries also brings them into a position where they have an important role in addressing the rapidly rising environmental crisis. The availability of metals (some of the elements used in alloys are among the most abundant ones), efficient mass producibility, low price and amenability to large-scale industrial production (from extraction to the metal alloy) and manufacturing (downstream operations after solidification) have become a substantial environmental burden: worldwide production of metals leads to a total energy consumption of about 53 exa Joules (8% of the global energy used) and 35% of industrial CO_2-equivalent emissions (4.4 giga tons of carbon dioxide equivalent) when counting only steels and aluminium alloys (the largest fraction of metal use by volume) [1]. This lecture discusses methods for improving the direct sustainability of structural metals, in areas including reduced-carbon-dioxide primary production [3,4], recycling, scrap-compatible alloy design, contaminant tolerance of alloys and improved alloy longevity. The lecture also discusses the effectiveness and technological readiness of individual measures and also shows how novel structural materials enable improved energy efficiency through their reduced mass, higher thermal stability and better mechanical properties than currently available alloys [2].

Dierk Raabe studied music, metallurgy and metal physics. After his doctorate 1992 and habilitation 1997 at RWTH Aachen in Germany he worked at Carnegie Mellon University (Pittsburgh) and at the National High Magnet Field Lab (Tallahassee) and joined Max Planck Society as a director in 1999. His interests are in sustainable metallurgy, hydrogen, microstructures, alloy design, computational materials science and atom probe tomography. We received the Leibniz award (highest German research award) and an ERC Advanced Grant (highest European grant). He is a Professor at RWTH Aachen (Germany) and KU Leuven (Belgium).

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