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MSEC Seminar and Commercialization Forum

Invited Speaker:

Dr. Miha Zakotnik

"The future of waste NdFeB rare earth permanent magnets and their role in a circular economy"

February 1st, 2019
1:30 – 3:00 PM
RFM 3241

Biography:
Miha Zakotnik qualified with a BSc in Chemical Engineering at the University of Ljubljana (Faculty of Chemistry and Chemical Technology) in 2002. He went on to study a masters (qualified 2004) and PhD on the recycling of Neodymium Iron Boron Magnets (qualified 2008) where he develop recycling process called MAGNET RECYCLING which was patented by the University. After a brief working as a research associate on recycling NdFeB permanent magnets he was employed as a research fellow studying recycling NdFeB permanent magnets and single crystal materials also at the University of Birmingham. Before moving to magnet industry Miha spend a short time as a research associate at University of Delaware working on synthesis of NdFeB nano particles and Beijing Technical University where he helped managing research group working on rare earth permanent magnets.

As part of industrial experience at YSM, Miha determine directions, priority and budget for research efforts interfacing with customers, engineering, and manufacturing. Miha set up the research laboratory and quality control points with YSM which is today one of the best NdFeB magnet manufacturing plant in China.

In 2014 Miha co-found Urban Mining Company, where he acts as a managing director and board member. Mihas day to day activities at Urban Mining Company (USA), are interfacing with direct advanced research in magnetic materials and applications interfacing with: investment, mergers, NdFeB sales & marketing, customers, engineering, manufacturing and

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maintaining and developing intellectual property portfolio. Miha work focuses on lots of different kinds of rare earth permanent magnet materials and magnet processing technologies, focusing on: rare earth NdFeB-type sintered magnets, recycling, grain boundary engineering of magnetic materials.

Miha and co-workers have developed a novel, patented neodymium-iron-boron (NdFeB) permanent magnet recycling technology known as the Magnet-to-Magnet (M2M®) recycling process. M2M® is a process whereby scrap NdFeB materials are harvested from end-of life devices, reduced to a fine powder, pressed, and then sintered into newly engineered NdFeB magnets. One of his major innovations is the ability to mix NdFeB scrap with varying starting compositions while controlling the output of the magnetic properties. Uniquely, M2M® produces magnets with higher magnetic flux, increased resistivity, and better thermal stability, with up to 60% less dysprosium (one of the more environmentally damaging, and expensive rare earths to produce) than traditional manufacturers. We achieve these properties because our technology selectively modifies the composition and microstructure of the inter-granular material to achieve high coercivity and enhanced temperature stability. This technological breakthrough allows UMC to engineer NdFeB magnetic systems for high temperature applications with less dysprosium, while still meeting one of the most pressing quality requirements – magnetic performance at high operating temperatures – at a reduced material cost.

Throughout his career, Miha has been particularly interested in the strategic challenges faced by recycling within permanent- magnet industry and its supply chain. The face of growing demand of rare earth permanent magnets as well as the increased use of rare earths in the areas of renewable-energy remains a a long-term vision of a green economy.

Abstract:

The industrial sector, which largely comprises of material producers, like chemical companies, mining operations, and metal manufacturers, is a driving force for growing global energy demand. Ultimately, material producers, like those that are part of the NdFeB magnet supply chain, will need to consume more energy with a growing demand for materials and a growing need for energy intensified mining operations, as availability to primary ore concentrations decline. The cumulative waste output of NdFeB magnets, which yields more than 500 thousand tones, is available for use as a material feedstock for the magnet-to-magnet

recycling process, and can drastically offset energy demand in the same way that recycling iron, aluminum, and copper achieved for their respective industries. Considering that the industrial sector draws its energy consumption from fossil fuels, material producers are largely responsible for carbon emissions. The problem is that most producers within the industrial sector are reaching their technical limitations to drastically improve energy efficiency.

The magnet-to-magnet recycling process, which has been scaled up and implemented at UMC, expands the technical limitations of traditional sintered neo manufacturing. The magnet-to-magnet recycling process is working not only on a laboratory scale, but also on a commercial scale, and has a measurable impact on the environment when compared to the traditional NdFeB sintered magnet supply chain.

More specifically, the recycling process is now gaining more attention and is regarded as an alternative production route for the manufacture of either fully dense sintered NdFeB-type magnets or bonded NdFeB magnets. The magnet-to-magnet recycling technique has a number of important advantages over the conventional route and results in a significant environmental benefit. One of its advantages is in the energy saving and ecological footprint due to the modified processing route of manufacturing recycled magnets. The waste feedstock is 100% used and the magnetic performance of the final product can be tailored through grain boundary engineering to achieve homogeneous batches in mass production. The first recycled magnets produced commercially to date have improved magnet performance that is equal in quality and performance to magnets used in the entire spectrum of industrial applications.

To address the future sustainability of specific critical rare earth metals, such as Tb, Dy, Nd, etc., circular economy policies are being implemented with end of life applications containing rare earth permanent magnets to reuse this precious resource. This is in line with the established WEEE directive.

NdFeB-based magnets have high magnetic energy densities (energy products) and, thus, are the most appropriate material of choice for the electronic industry, medical sector, or motors used within electric/hybrid vehicles, where permanent magnetic material must be as small, lightweight, and efficient as possible. Recent trends to move towards a greener economy (requiring the use of NdFeB), as well as increasing demand for the rare earths, have put additional stress in the available supply of materials to produce NdFeB-type permanent magnets. A serious effort to recycle NdFeB-type materials started around 2000, and commercial scale recycling NdFeB magnets via the magnet-to-magnet route is one method to mitigate large price fluctuations and material availability going forward. The manufacture of NdFeB magnets by the magnet-to-magnet process makes use of end-of-life 'waste' NdFeB as a feedstock material. The recycled magnets produced have been up-cycled from 'waste' NdFeB feedstock to new magnets with increased magnetic performance by the unique processing route and microstructure formed. One example is the performance of two nearly identical electric motors, which have been compared: one motor containing recycled NdFeB magnets produced via the magnet-to-magnet processing, and the other motor containing conventional NdFeB magnets made from virgin elements. The results demonstrate that flux linkage measured at open circuit and the torque measured at closed circuit are 7.0% and 6.4% higher, respectively, for the motor containing recycled magnets versus the motor containing conventional magnets. This was achieved despite the 15% lower Dy content of the recycled magnets as compared to conventionally produced magnets. This performance advantage demonstrates the viability of the magnet-to- magnet recycled NdFeB technology in real world applications.

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PLEASE CONTACT DR. SHANNON WEIGUM AT SWEIGUM@TXSTATE.EDU