Seminar announcement

Tuesday, November 25, 2025
1:00 pm
WSI, Seminar room S 101
Exclusively in person

"Single-spin sensors for studying surface magnetism: Improving noble metal catalysts by engineering their nanomagnetic properties"

Nobel metals such as palladium nanomaterial are of extreme importance as catalysts. Almost 90 % of the worldwide palladium consumption is for use in car catalytic converters and catalysis in chemical industries [1]. While usually paramagnetic, palladium can turn ferromagnetic at the nanoscale [4]. Other noble metals also exhibit so far unexplained ferromagnetism at the nanoscale [5,6]. This is of high importance, since ferromagnetism has recently been linked to enhanced catalytic activity [2,3].

We investigate the origin of palladium and other noble metal ferromagnetism using single spin quantum sensors. Our goal is engineering the noble metals' nanomagnetic properties to make them better catalysts. In muon spin rotation studies, we performed a magnetic depth-scan of a palladium sample by implanting muons at different depths as local magnetic probes. With this method, we found a slight increase of the magnetic field at the palladium surface [7], potentially originating from induced orbital magnetic moments related to surface adsorbates [8,9]. We also found signs of a paramagnetic to ferromagnetic phase transition that happens at the surface only. This is highly relevant to catalysis since reactants adsorb at the palladium surface during the catalytic reaction.

To gain further understanding of this palladium surface magnetic state, we propose magnetic imaging experiments using color centers in diamond as ultrasensitive magnetic field sensors. We also want to image the nanoscale surface magnetism of other noble metals and look for correlations of nanomagnetic properties with catalytic activity.

[1] *Norilsk Nickel. (May 24, 2024) In Statista. Retrieved October 28, 2024, from https://www-statista-com.tudelft.idm.oclc.org/statistics/693767/ palladium-global-consumption-by-industry/*
[2] *Sampedro et all PRL 91, 237203 (2003)*
[3] *Tuboltsev et al. ACS Nano 7, No. 8, 6691–6699 (2013)*
[4] *Li et al. J. Appl. Phys. 116, 033911 (2014)*
[5] *Biz et al. ACS Catal., 11, 14249–14261 (2021)*
[6] *Li et al. Adv. Mater. 35, 230296 (2023)*
[7] *Welker et al. arXiv:2209.02002 (2022)*
[8] *Hernando et al. PRB 74, 052403 (2006)*
[9] *Hernando et al. PRL 96, 057206 (2006)*

Dr. Gesa Welker
TU Delft / TU Eindhoven
The Netherlands