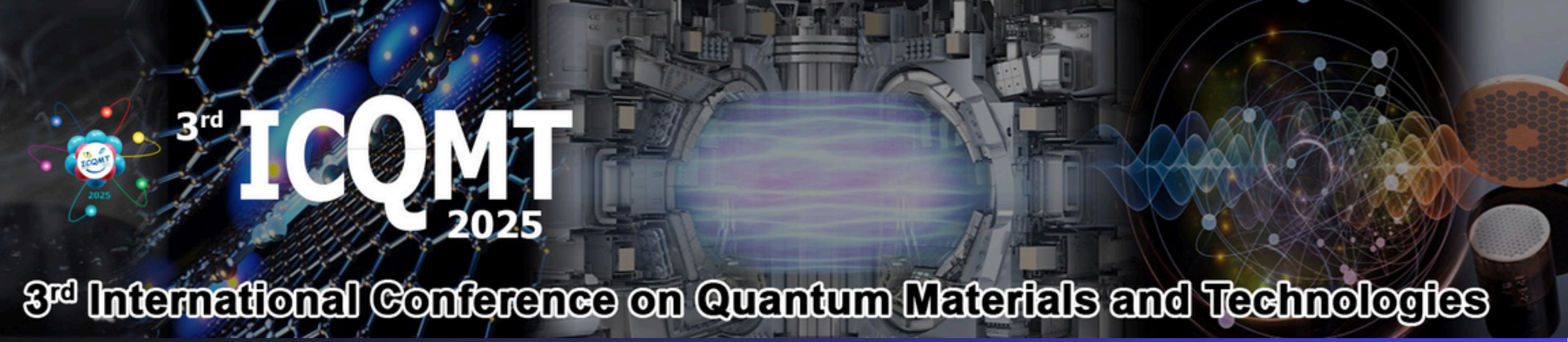

Happy Ending to a 50-year-old Mystery: Scientific Breakthroughs of α''-$Fe_{16}N_2$ Leading to Environmentally-Friendly Permanent Magnet and Discovery of a New Soft Magnetic Material - Minnealloy α''-$Fe_{16}(NC)_2$

Distinguished Professor Jian-Ping Wang

Jian-Ping Wang is a Distinguished McKnight University Professor and the Robert F. Hartmann Chair of Electrical and Computer Engineering at the University of Minnesota. He got his BS in physics from Lanzhou University and his PhD in physics from the Institute of Physics/CAS, Beijing. He is a fellow of National Academy of Inventors, a fellow of Institute of Electrical and Electronics Engineers (IEEE) and a fellow of American Physical Society (APS). He was the director of the Center for Spintronic Materials for Advanced Information Technology (SMART), a SRC-NIST program and the Center on Spintronic Materials, Interfaces and Novel Architectures (C-SPIN), a SRC-DARPA program. He is a recipient of the Outstanding Professor Award for his contribution to undergraduate teaching in 2010. He received the information storage industry consortium (INSIC) Technical Achievement Award in 2006 for his pioneering experimental effort on the exchange-coupled composite media (ECC), which has been used for today's HDD industry. He is the recipient of 2019 Semiconductor Research Corporation (SRC) Technical Excellence Award for his pioneering work on nanomagnetics and spintronic devices that have been used in today's STT-RAM products. He is the recipient of 2024 IEEE Magnetic Society Achievement Award.

Date and Time: From 26 April to 3 May 2025, exact day&time will be announced later.

Lecture Room: TBD

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Abstract

α″-Fe16N2 had been viewed as a mystery material since its first magnetic measurement report in 1972,
including unavailable condense matter physics model, non-repeatable experiments for its giant saturation magnetization and many other controversial reports at two dedicated symposia in 1994 and 1996 MMM conference, respectively. The topic was then largely dropped by the magnetic research community since the end of 1990s. Key scientific breakthroughs around this material have been made through our 8-year long and persistent efforts in Minnesota with a joint force across DOE labs, first reported in APS 2010 and then at INTERMAG 2012 [1], including the direct observation of its giant saturation magnetization by polarized neutron reflectivity (PNR), the discovery of partial localization of 3d electrons through XMCD measurement and a proposed Cluster + Atom theory by DFT calculation. We further confirmed its engineering feasibility for permanent magnets from 2011 to 2014 through a DOE ARPA-E support. Since then, α″-Fe16N2 has been picked up as one of the most promising rare-earth-free magnet candidates and the only one being commercialized because of its use of environmentally-friendly raw materials [2,3], confirmed giant saturation magnetic flux density (2.9 T), and reasonably high magnetic anisotropy constant (1.8 MJ/m3). Its coercivity temperature coefficient (~ 0.4 Oe/°C) in the range of 27–152 °C is two orders of magnitude lower than that of commercial NdFeB magnets (e.g. N40 ~ -81.9 Oe/K) [4]. Our recent polarized neutron diffraction (PND) provided the direct measurement of the magnetic moment for each iron site and confirmed our proposed cluster + atom model for Fe16N2 [5]. The iron nitride magnet is of great interest as a magnetic material for applications working at relatively low temperature (<180 oC) and NOT requesting high coercivity. These applications range from speaker magnets to magnets in wind turbines, smart phones, audio devices, and other power generation machines. A perspective review on the recent scientific breakthroughs and the synthesis of the bulk α″-Fe16N2 compound permanent magnet is presented here on the aspects of material processing and magnetic characterizations. Strategies to enhance its coercivity will be presented [6,7]. For the 2nd part of my talk, I will also report to you our discovery and recent progress of a soft magnetic material, Minnealloy α″-Fe16(NC)2[8,9,10], which could be potentially used for magnetic recording head, electric systems and transformers.

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