Reconfigurable All-Nitride Magneto-Ionics

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The rapid advancement of generative artificial intelligence has significantly increased the demand for both energy and data storage. Magneto-ionics, which utilizes ionic motion to control magnetism, often driven by an electric field in heterostructures, has gained significant attention for its potential to enable energy-efficient modulation of magnetic properties with large effects. This study proposes a unique COMS-compatible solid-state magneto-ionic system composed of all Mn nitrides and demonstrates that nitrogen ionic motion can induce reversible phase transitions between ferrimagnetic and antiferromagnetic Mn nitrides [1, 2]. This magnetic phase transition is manifested in dramatic changes in the resultant exchange bias effect which can be increased by over an order of magnitude when more nitrogen is introduced into the nitrides during deposition and subsequently reduced by over 70% when nitrogen is taken out of the nitrides through post-annealing. Additionally, voltage-induced nitrogen ionic motion can lead to reversible changes in saturation magnetization and exchange bias effect by 23% and 0.1 T (16%) at 5 K, respectively. These findings highlight the potential of this all-Mn-nitride system as an industrially viable and environmentally sustainable platform, offering tunable magnetic properties and energy-efficient operation, and potential for magnetic field immunity.

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2 Z. J. Chen, C. J. Jensen, C. Liu, Y. J. Liu, C. J. Kinane, A. J. Caruana, A. J. Grutter, J. A. Borchers, X. X. Zhang, and K. Liu, ACS Nano, to appear (2025).