Designer enhanced magnon transport in epitaxial, multiferroic heterostructures grown by molecular-beam epitaxy

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Bismuth ferrite (BFO) is a room temperature magnetoelectric multiferroic with antiferromagnetic order and a large spontaneous polarization. In recent years, it has gained interest in the spintronics community for its use in non-volatile logic-in-memory devices. However, efficiently controlling the magnons in this material remains a challenge. Using molecular-beam epitaxy, we can precisely control the thickness and quality of each layer allowing for the creation of designer magnon transport. For this work, we grew samples of $REFeO_3/BiFeO_3/REFeO_3$ (RE = rare earth elements such as La, Dy) and observed highly efficient magnon transport in an all-antiferromagnetic system that can be controlled electrically due to the coupling of the ferroelectric and antiferromagnetic ordering in $BiFeO_3$. Leveraging spin-orbit-driven spin-charge transduction, we demonstrate that this material architecture permits magnon confinement in ultrathin antiferromagnets, enhancing the output voltage generated by magnon transport by several orders of magnitude, which provides a pathway to enable magnetoelectric memory and logic functionalities. Additionally, its non-volatility enables ultralow-power logic-in-memory processing, where magnonic devices can be efficiently reconfigured via electrically controlled magnon spin currents within magnetoelectric channels. Notably, by changing the thickness and rare earth elements of the $REFeO_3$ layers can modulate the enhancement of the spin transport.