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Paramagnetic and Antiferromagnetic Spin Seebeck Effect

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We report on the observation of the longitudinal spin Seebeck effect in both antiferromagnetic and paramagnetic insulators. By using a microscale on-chip local heater, it is possible to generate a large thermal gradient confined to the chip surface without a large increase in the total sample temperature. This technique allows us to easily access low temperatures (200 mK) and high magnetic fields (14 T) through conventional dilution refrigeration and superconducting magnet setups. By exploring this regime, we detect the spin Seebeck effect through the spin-flop transition in antiferromagnetic MnF_2 when a large magnetic field (>9 T) is applied along the easy axis direction. Using the same technique, we are also able to resolve a spin Seebeck effect from the paramagnetic phase of geometrically frustrated antiferromagnet $Gd_3Ga_5O_{12}$ (gadolinium gallium garnet) and antiferromagnetic $DyScO_3$ (DSO). Since these measurements occur above the ordering temperatures of these two materials, short-range magnetic order is implicated as the cause of the spin Seebeck effect in these systems. The discovery of the spin Seebeck effect in these two materials classes suggest that both antiferromagnetic spin waves and spin excitations from short range magnetic order may be used to generate spin current from insulators and that the spin wave spectra of individual materials are highly important to the specifics of the longitudinal spin Seebeck effect. Since insulating antiferromagnets and paramagnets are far more common than the typical insulating ferrimagnetic materials used in spin Seebeck experiments, this discovery opens up a large new class of materials for use in spin caloritronic devices. All authors acknowledge support of the U.S. Department of Energy (DOE), Office of Science, Basic Energy Sciences (BES), Materials Sciences and Engineering Division. The use of facilities at the Center for Nanoscale Materials, was supported by the U.S. DOE, BES under contract No. DE-AC02-06CH11357.