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Experimental observation of the spin-Hall effect in a two dimensional spin-orbit coupled semiconductor system[1]

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The Hall effects are among the most recognized families of phenomena in basic physics and applied microelectronics. The ordinary and quantum Hall effects, which, e.g., proved the existence of positively charged carriers (holes) in semiconductors and led to the discovery of fractionally charged quasiparticles, occur due to the Lorentz force that deflects like-charge carriers towards one edge of the sample creating a voltage transverse to the current. In the anomalous Hall effect, the spin-orbit interaction plays the role of the force that deflects like-spin carriers to one edge and opposite spins to the other edge of the sample. In a ferromagnetic material this leads to a net charge imbalance between the two sides which allows to detect magnetization in the conductor by simple electrical means. Here we report the experimental discovery of a new member of the Hall family - the spin-Hall effect (SHE). As an analogue of the anomalous Hall effect but realized in non- magnetic systems the SHE opens new avenues for inducing and controlling spin-currents in semiconductors without applying magnetic fields or introducing ferromagnetic elements. To demonstrate the SHE, we have developed a novel p-n junction light emitting diode microdevice. Its co-planar geometry and the strong spin-orbit coupling in the embedded two-dimensional hole gas are well suited for inducing and detecting the SHE. When an electric field is applied across the hole layer, a non zero out-of-plane component of the spin is optically detected whose sign depends on the sign of the field and is opposite for the two edges, consistent with theory predictions.

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