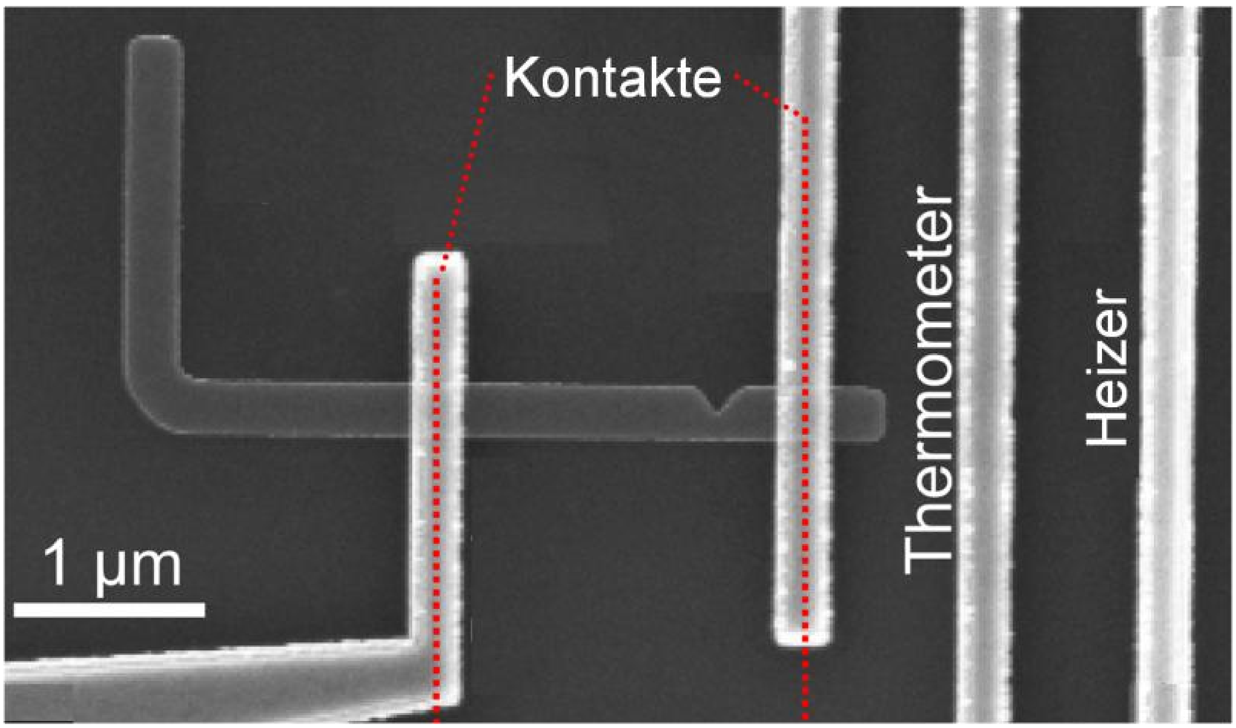
First measurement of the thermoelectric properties of a single magnetic domain wall

October 15 2015



Bent magnetic nanowire made of a nickel/iron alloy. The heating wire (right) generates a temperature difference between the electric contacts of the nanowire. If a magnetic wall is captured at the indentation, the thermoelectric voltage measured between the contacts changes. Credit: PTB

Magnetic nanostructures – or rather: the interaction between charge, spin and current flow as a function of a temperature gradient in such structures – this is what the fast growing research area named "spin caloritronics" deals with. And this area of research has already come up with a number of newly discovered interesting effects and promising applications. Scientists from the Physikalisch-Technische Bundesanstalt (PTB) have, for the first time, succeeded in measuring the thermoelectric properties of a single magnetic domain wall. The results have been published in the current issue of the renowned scientific journal *Physical Review B* and have even been emphasized as an Editors' Suggestion. Magnetic domain walls occur in all macroscopic and nanoscale magnetic materials and components. This is the reason why the fact that not only the magnetic and electric properties, but also – for the first time – the thermoelectric properties of these fundamental magnetic structures can be detected and described, is important for a whole series of applications.

As early as in 1821, physicist Thomas Johann Seebeck discovered that a temperature difference between the two ends of a metallic wire generates an electric voltage between the ends of this wire. Today, this so-called "Seebeck effect" is used, for example, in thermocouples to directly convert waste heat into electric energy. The size of the electric voltage generated hereby depends not only on the electric, but also on the magnetic properties of the material. Thus, in a ferromagnetic material (such as iron), the Seebeck coefficient changes when the magnetization is turned around in an external magnetic field. This behavior is also called the "magneto-Seebeck effect".

At PTB, the thermoelectric properties of single magnetic nanowires have now been investigated in detail for the first time. If, in a magnetic nanowire, two differently poled areas come into contact with each other, a magnetic domain wall occurs in the transition area. Hereby, the presence or absence of the domain wall manifests itself by a change in the electric resistance of the wire which can be measured via electric contacts.

The recent investigations have shown for the first time that the presence or absence of the domain wall also leads to a measurable change in the thermoelectric voltage generated by the wire. For this purpose, the experiments carried out consisted in heating one side of the wire with an electric heater and in measuring the Seebeck voltage via two contacts (see figure). An indentation in the wire allowed the scientists to capture exactly one single magnetic domain wall between the contacts and to determine the resulting difference in the Seebeck voltage. It turned out that the domain wall's magneto-Seebeck effect leads to an increase in the total thermoelectric voltage measured in the nanowire.

Magnetic domain walls occur in all macroscopic and nanoscale magnetic materials and components. The results, which have now been published, allowed not only the magnetic and electric properties, but also the thermoelectric properties of these fundamental magnetic structures to be detected and described.

More information: Patryk Krzysteczko et al. Domain wall magneto-Seebeck effect, *Physical Review B* (2015). DOI: 10.1103/PhysRevB.92.140405

Provided by Physikalisch-Technische Bundesanstalt

Citation: First measurement of the thermoelectric properties of a single magnetic domain wall (2015, October 15) retrieved 25 April 2024 from https://phys.org/news/2015-10-thermoelectric-properties-magnetic-domain-wall.html