

Supporting Information

S1 Evidence of vortex formation at intermediate positions:

The formation of vortices at intermediate positions in diameter modulated nanowires was predicted by simulations in ref [10]. The MFM image in Figure S1 experimentally demonstrates the presence of vortices at these intermediate positions.

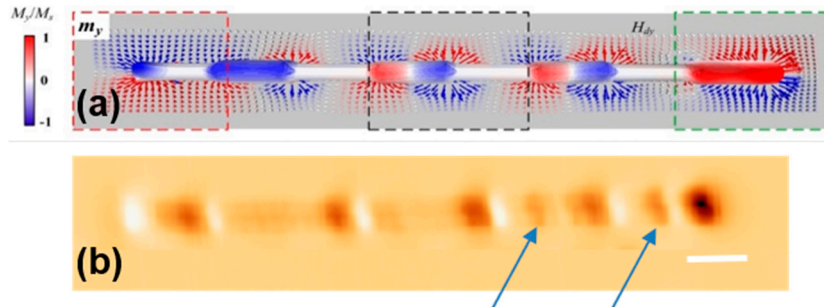


Figure S1. (a) Simulated magnetization configuration of a diameter modulated nanowire, showing vortex formation at intermediate positions. Reprinted with permission from Rodríguez, L. A. *et al.* Quantitative Nanoscale Magnetic Study of Isolated Diameter-Modulated FeCoCu Nanowires. *ACS Nano* **10**, 9669–9678 (2016), Copyright 2016 American Chemical Society. (b) MFM image of NW with longer thick segments, displaying intermediate contrast related to vortex formation, marked with arrows.

S2 Negligible variations in the oscillation amplitude signal during 3D imaging:

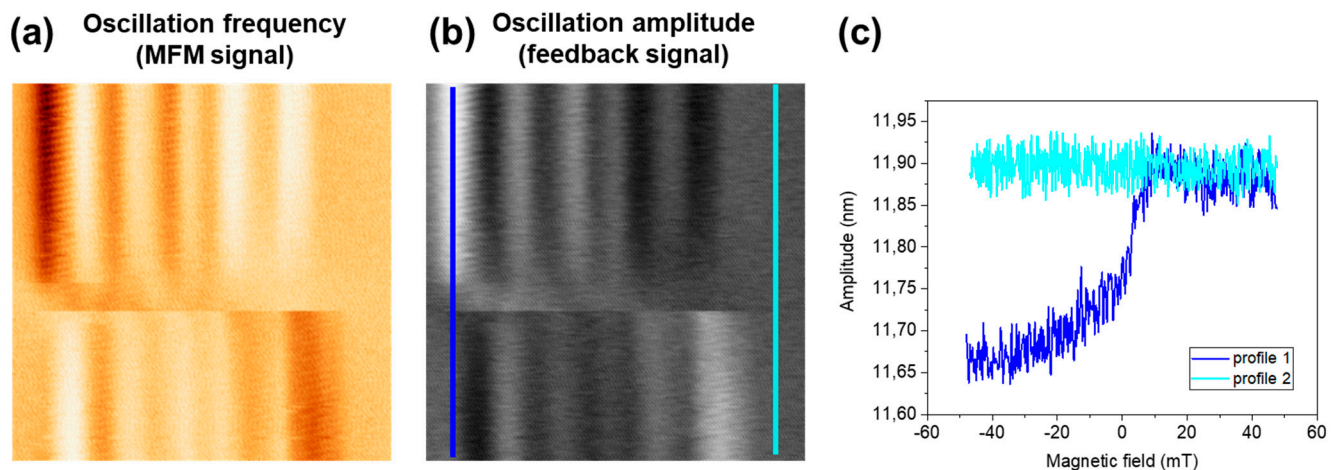


Figure S2. (a) 3D mode image of the magnetic signal showing evidence of skyrmion tube. (b) Corresponding oscillation amplitude data. (c) Oscillation amplitude profiles taken from the image in (b).

S3 Single Barkhausen jump in short thick segment nanowires:

Although many nanowires with short thick segments present skyrmion-tube mediated magnetization reversal processes, in some cases we have also detected a single-barkhausen jump mediated magnetization reversal, as shown in the 3D mode images displayed in Figure S3.

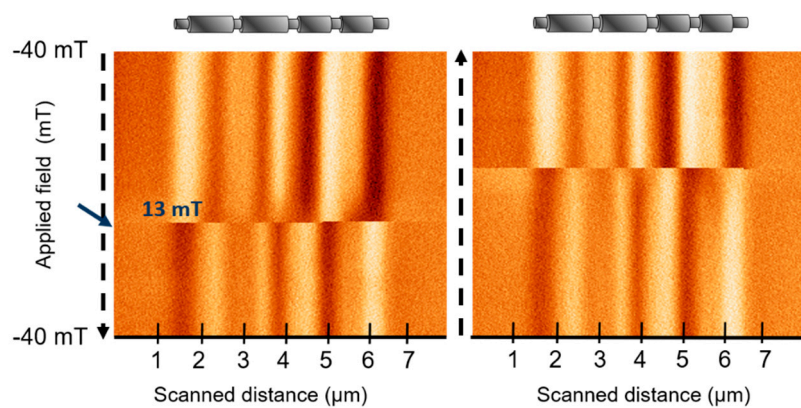


Figure S3. 3D mode imaging of the magnetization reversal happening through a single Barkhausen jump.