Planar Josephson junction as an element for novel superconducting devices

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Introduction

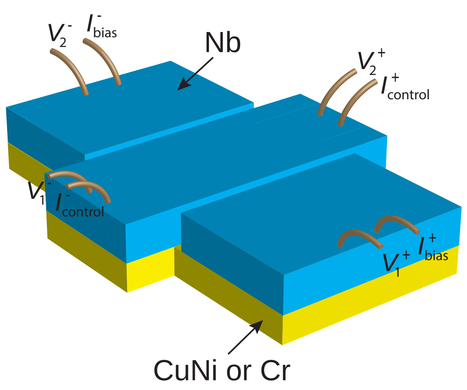
In this work we demonstrate prototypes of two types of devices based on a planar Josephson junction:

(i) Abrikosov vortex-based memory cell [1]. We use single vortex as an information bit and a planar Josephson junction for read-out of vortex state. The vortex is manipulated by short current pulses.

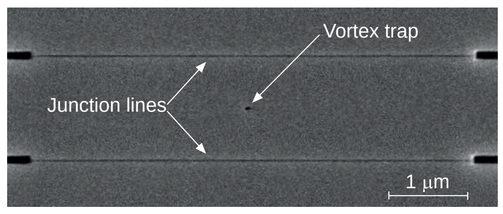
(ii) Scanning-probe sensor [2]. We fabricate and analyze experimentally sensor prototypes with a CuNi/Cr barrier. We demonstrate that the planar geometry facilitates an effective utilization of the self-field phenomenon for amplification of sensitivity and a simple implementation of a control line for feedback operation.

Devices

Double planar JJ:

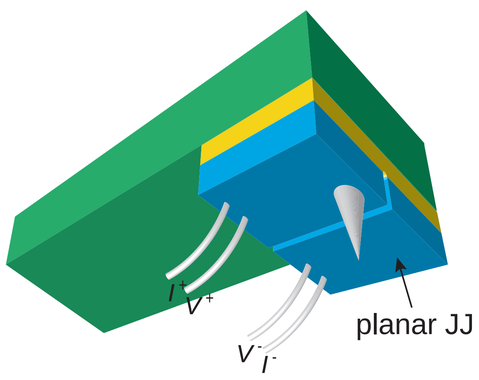


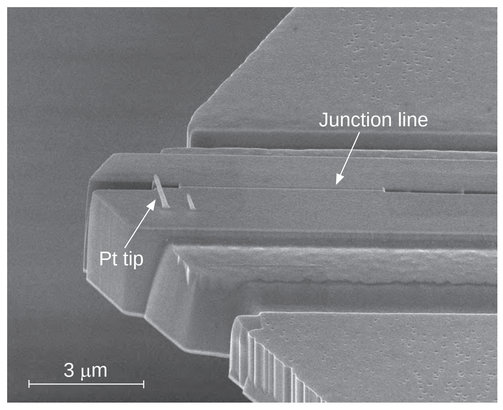
Vortex-based memory cell



Scanning-probe sensor

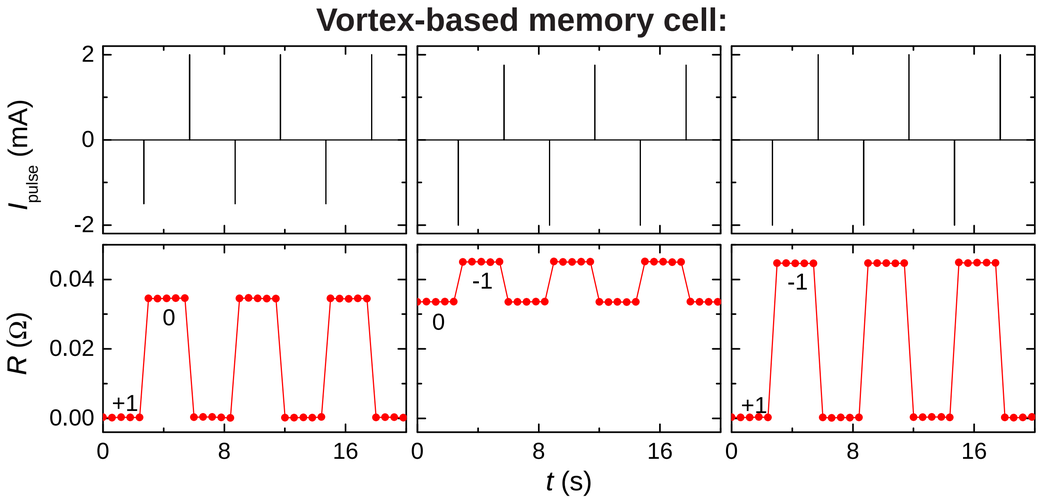
Single planar JJ on AFM cantilever:



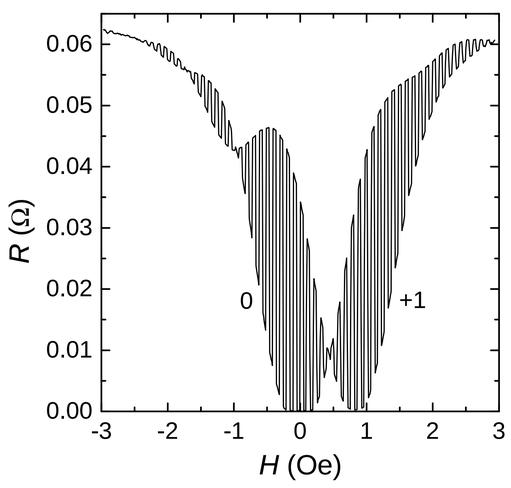


Device performance

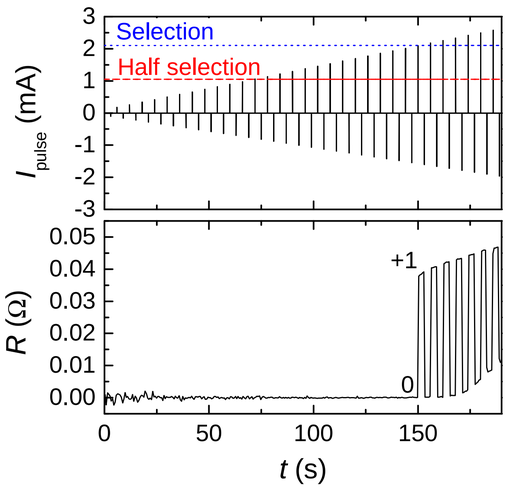
Vortex-based memory cell:



Demonstration of write and erase operations by current pulses of different amplitudes.

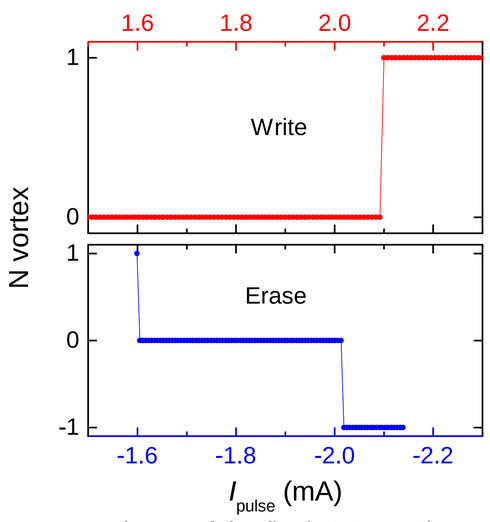


Controllable 0–1 switching in a broad field range.

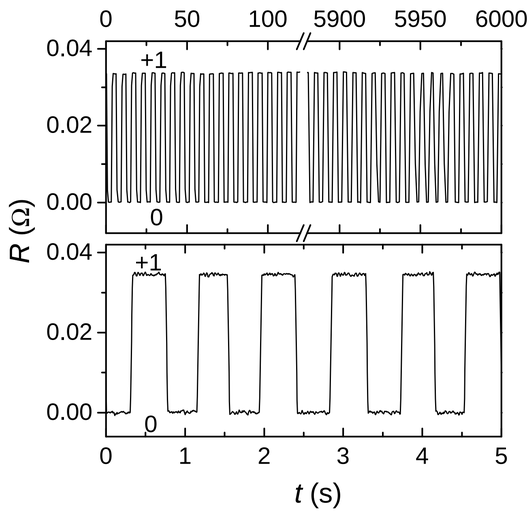


Evolution of the device state on applying a pulse train with growing amplitude.

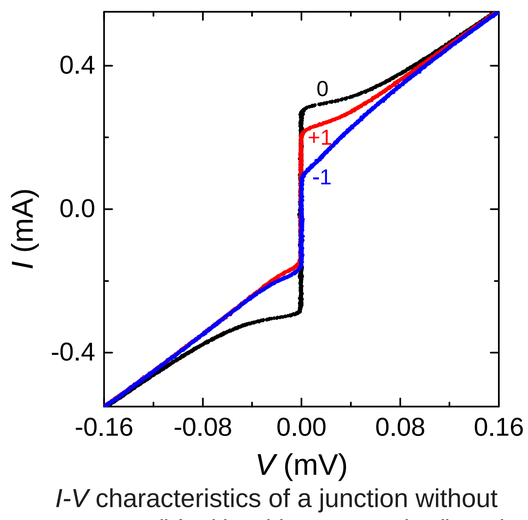
Device performance



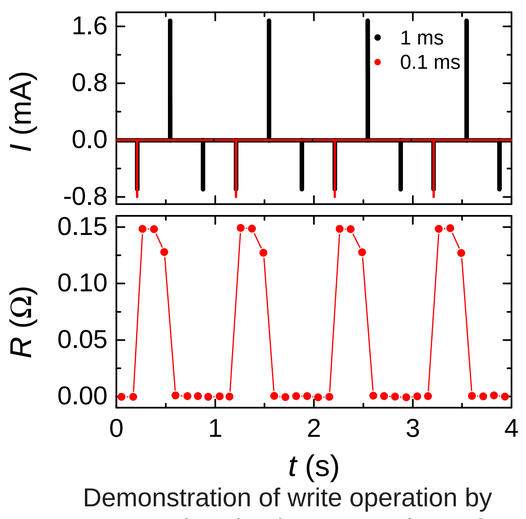
Dependence of the final state on the pulse amplitude.



Demonstration of high-endurance 0–1 switching at zero applied field.

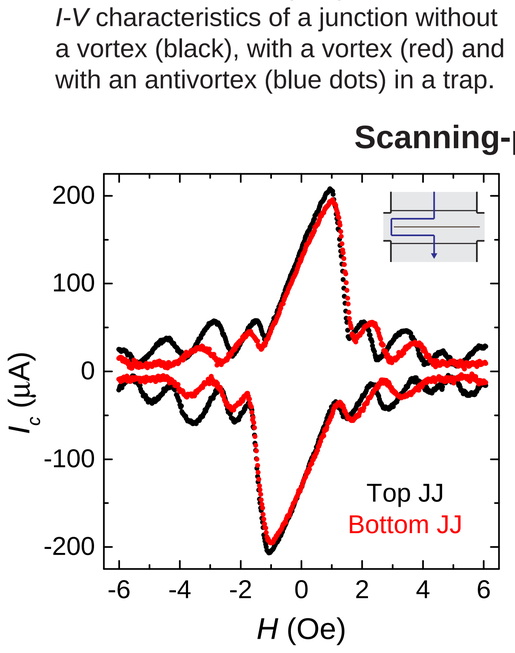


I-V characteristics of a junction without a vortex (black), with a vortex (red) and with an antivortex (blue dots) in a trap.

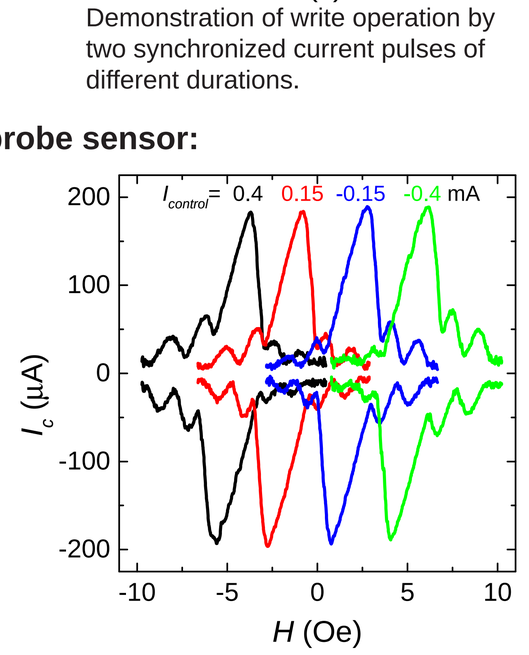


Demonstration of write operation by two synchronized current pulses of different durations.

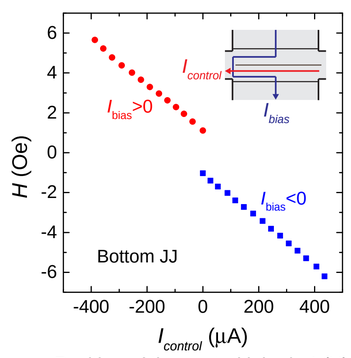
Scanning-probe sensor:



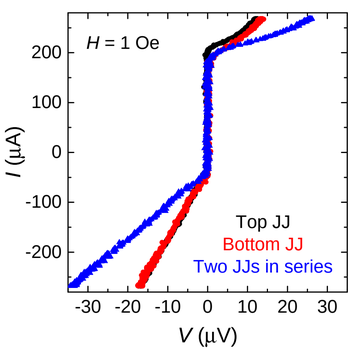
$I_c(H)$ patterns for both junctions on a sample with a separating cut.



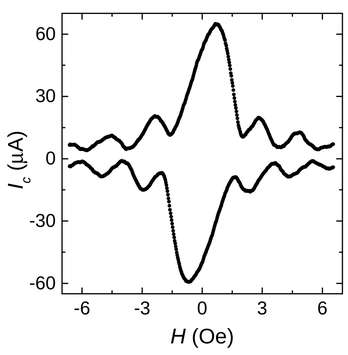
Offset of $I_c(H)$ patterns of the bottom junction at four control currents.



Position of the central lobe in $I_c(H)$ for positive and negative I_c as a function of the control current.



I-V characteristics of both junctions and their serial connection. Note doubling of the readout voltage.



$I_c(H)$ pattern of the junction fabricated on AFM cantilever.

References

[1] T. Golod, A. Iovan and V.M. Krasnov, Nature Commun. 6, 8628 (2015).
[2] T. Golod, O.M. Kapran and V.M. Krasnov, Phys. Rev. Applied 11, 014062 (2019).

Acknowledgements

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