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ABSTRACT BOOK

NANOSCALE SUPERCONDUCTIVITY,
FLUXONICS AND PHOTONICS:
ADDRESSING GRAND CHALLENGES

KU LEUVEN METHUSALEM GROUP

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Theoretical Description of SIsFS Device

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In recent years Josephson junctions with ferromagnetic F layers became one of the most desirable and actively developed devices in superconductive electronics. The oscillating nature of superconductive proximity effect in the magnetics leads to appearance of π state and provides opportunities to develop a wide range of applications. Unfortunately, characteristic voltage, I_CR_N, of conventional SFS junctions is much smaller than that of tunnel SIS devices, which are widely used in superconductive electronics. This leads to deficient value of characteristic frequency and to difficulties in integration with other circuits. Recently, successful realization of switchable Nb-Al/AlO_x-Nb-$Pd_{0.99}Fe_{0.01}$-Nb junctions was reported in [1-2]. These junctions are of SIsFS type, i.e., a serial connection of the SIs tunnel junction and sFS sandwich. These SIsFS structures have high characteristic voltage I_CR_N up to 700 μV, due to the presence of tunnel barrier I. At the same time they behave as a single junction with respect to an external magnetic field, Hext, since intermediate layer s is too thin to screen it. We have performed a theoretical study of magnetic SIsFS Josephson junctions in the frame of Usadel equations. Josephson current is calculated numerically in self-consistent manner. We outline several modes of operation of these junctions and demonstrate their unique ability to have high I_CR_N product in the π state. We develop a model describing asymmetric nature of Fraunhofer pattern $I_C(H_{ext})$ in these devices. This model describes switching of the Josephson critical current by an external magnetic field. The results are in good agreement with the experimental data and demonstrate suitability of these structures for integration into high-speed energy-efficient SFQ digital circuits.

[1] T. I. Larkin et al, Appl. Phys. Lett. 100, 222601 (2012).
[2] I. V. Vernik et al, IEEE Trans. Appl. Supercond. 23, 1701208 (2013).

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