TT 1 Superconductivity: Tunnelling, Josephson Junctions, SQUIDs

Time: Monday 09:30–11:15 Room: HSZ 02

TT 1.1 Mon 09:30 HSZ 02

Intrinsic Josephson junction on misaligned Tl-2212 thin films with different tilt angle — •Michael Mans[1], Matthias Büenfeld[1], Henrik Schneidewind[2], Frank Schmidl[1], Marco Diegel[2], and Paul Seidel[1] — [1]Institute of Solid State Physics, Friedrich-Schiller-University Jena, Helmholtzweg 5, D 07743 Jena, Germany — [2]Institute for Physical High Technology (IPHT) Jena, P.O.B. 100239, D 07702 Jena, Germany

Tl-2212 films are grown in a two step process. An amorphous Ba-Ca-Cu-O precursor are sputtered by rf sputtering. Subsequent it will oxythallinized into the Tl-2212 phase. On misaligned $LaAlO_3$ substrates the Tl-2212 grows with Cu-O planes tilted to the surface. So it is possible to fabricate microbridges which contain serial arrays of intrinsic Josephson junctions. We present structural and electrical measurements on such arrays for different misalignment angles. The electrical behaviour will be discussed in respect to the possibility of phase synchronisation. The experimental data will be compared with theoretical calculations of serial arrays of Josephson junctions with and without shunts.

TT 1.2 Mon 09:45 HSZ 02

Enhanced Macroscopic Quantum Tunneling in $Bi_2Sr_2CaCu_2O_{8+\delta}$ Intrinsic Josephson Junction Stacks — •X.Y. Jin, J. Lisenfeld, Y. Koval, A. Lukashenko, A.V. Ustinov, and P. Müller — Physikalisches Institut III, Universität Erlangen-Nürnberg, Germany

We have investigated macroscopic quantum tunneling (MQT) in $Bi_2Sr_2CaCu_2O_{8+\delta}$ intrinsic Josephson junctions (IJJs) and performed spectroscopic measurements. Classical-to-quantum crossover temperatures T* of up to 700mK were found. Plasma frequencies ω_p of up to 1.13 THz have been observed. We discovered that T* of IJJ stacks is significantly enhanced in comparison to a single intrinsic junction having a comparable plasma frequency. This enhancement of MQT is due to the unique stacking structure of IJJs. The quality factor of the IJJ stacks is $Q \sim 50$ and the spectroscopic coherence time is $\tau \sim 1.3ns$. This will allow to observe Rabi oscillations at rather high temperatures.

TT 1.3 Mon 10:00 HSZ 02

Characterisation of Nb charge-phase qubit circuits at 4.2 — •J. Könemann, H. Zangerle, B. Mackrodt, R. Dolata, S.A. Bogoslovsky, M. Götz, and A.B. Zorin — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

Due to their scalability superconducting circuits, based on small Josephson junctions, are promising candidates for qubits, which form the basis of a possible quantum computing processor. The Bloch transistor included in a superconducting loop can serve as a so-called charge-phase qubit. Our all-Nb circuits with junction area down to 80 nm by 80 nm and nominal critical current of individual junctions of 25-50 nA included the Bloch transistor inserted into a loop and on-chip inductor of the tank circuit. Due to appreciable charging energy of the island the critical current of the transistor was substantially suppressed. High temperature made this suppression stronger. We report the radio-frequency measurements of our Nb qubit circuits, which were possible at 4.2 K. Resonance and flux modulation curves were used to determine the characteristic parameters of the samples. From the phase modulation curves the critical current (as small as few nA) and almost harmonic phase dependence of supercurrent were found. These data are consistent with our estimation based on a multi-band quantum-statistical model.

TT 1.4 Mon 10:15 HSZ 02

Frozen-flux-quanta phase shifter for digital Josephson circuits — •Dmitry Balashov[1], M. Khabipov[1], D. Hagedorn[1], A. B. Zorin[1], F.-Im. Buchholz[1], J. Niemeyer[1], B. Dimov[2], Th. Ortlepp[2], and F. H. Uhlmann[2] — [1]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany — [2]Technische Universität Ilmenau, 98684 Ilmenau, Germany

Superconducting Rapid Single Flux Quantum (RSFQ) digital circuits are very promising for integration with Josephson qubits of different types. The basic quantization condition of each RSFQ cell is given by $LI_c > \Phi_0$ (L is the loop inductance and $\Phi_0 \approx 2.07$ mV·ps is the single flux quantum). For qubit applications, the critical current I_c of the RSFQ circuits should be set to about several μA, which, in turn, requires large geometrical inductance of the loop to ensure a certain phase shift inside or between the cells. The replacement of large inductances by the novel passive phase shifting elements based on small integer numbers of flux quanta frozen in the superconducting loops provides the well-defined phase shift. We report on the experimental verification of operation of such compact passive phase shifter elements realised in standard niobium SIS-trilayer technology for two different critical current densities: $j_c = 100$ A/cm^2 ($I_c^{\min} = 10$ μA), and $j_c = 1$ kA/cm^2 ($I_c^{\min} = 125$ μA). The flux quanta injection to the phase shifter loops was managed by feeding proper current into specially designed control lines.

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TT 1.5 Mon 10:30 HSZ 02

Low frequency noise in shadow evaporated Josephson junctions — •Jonathan Eroms, L.C. van Schaarenburg, E. Driessen, K. Huizinga, J.H. Plantenberg, R.N. Schouten, A.H. Verbruggen, C.J.P.M. Harmans, and J.E. Mooij — Kavli Institute of Nanoscience Delft, TU Delft, The Netherlands

Shadow angle evaporation is a convenient technique to fabricate submicron size tunnel junctions for various applications in mesoscopic physics. Particularly, many realizations of superconducting qubits, both in the charge and flux regime, are manufactured in this way. Now that external sources of decoherence are well understood and increasingly well controlled, the intrinsic limitations of the junction technology become more important. We therefore measured the low frequency resistance fluctuations of a number of small Josephson junctions fabricated in the same manner as our flux qubits. While the low-frequency noise has a $1/f$ spectral density and drops sharply from room temperature down to about 5 K, the low temperature behavior down to 300 mK is always dominated by a small number of strong two-level fluctuators, and the noise strength saturates between 1 K and 600 mK. The consequences for qubit decoherence are discussed.

TT 1.6 Mon 10:45 HSZ 02

From 0 to π coupled Josephson junctions — •Martin Weides[1], Hermann Kohlstedt[1,2], Edward Goldobin[3], Dieter Koelle[3], and Reinhold Kleiner[3] — [1]Institute for Solid State Research, Research Centre Juelich, Germany — [2]Department of Material Science and Department of Physics, University of Berkeley, USA — [3]Physikalisches Institut - Experimentalphysik II, Universität Tübingen

We report on the successful fabrication of low- T_C SINFS Josephson junctions with 0 to π coupling transition as a function of d_F. Diluted ferromagnetic $Ni_{60}Cu_{40}$ is used as F-interlayer. Our technology [1] enables us to fabricate high quality junctions with low parameter spread. We studied [2] the dependence of I_c and β_C on the thickness of ferromagnet and on temperature for both coupling regimes. The influence of magnetic dead layer is investigated.
High $I_c \simeq 5$ A/cm^2 and $V_c \simeq 20$ mV for the π coupled state [2] are measured. For T below 3K the π coupled SINFS junction gets underdamped, indicating a rather weak Cooper pair breaking in the ferromagnetic layer. At the 0-π boundary half-integer vortices (semifluxons) may spontaneously appear. They are pinned at the 0-π-boundary and may have two different polarities with flux $\Phi = \pm\Phi_0/2$. The semifluxon represents the ground state of the system and therefore is extremely stable [3].
A patterning process of 0-π coupled SIFS junctions for the investigation of semifluxons was worked out and first results will be shown.
[1] Weides et al., to appear in Physica C
[2] Weides et al., to be submitted.
[3] E. Goldobin et al., PRB 66 (2002), 67 (2003), 69 (2004)

TT 1.7 Mon 11:00 HSZ 02

Decay of metastable states in annular Josephson junctions in the presence of external magnetic field — •Abdufarrukh A. Abdumalikov, Astria Price, Alexander Kemp, and Alexey V. Ustinov — Physikalisches Institut III, UniversitätErlangen-Nürnberg, Erlangen, Germany

We investigate numerically and experimentally thermal activation processes in annular Josephson junctions of different length L. Junctions with and without a trapped vortex are studied. The numerical analysis is performed using the perturbed sine-Gordon model with a thermal noise term. For long junctions ($L \sim 10\lambda_J$), the dependence of the switching

current histogram width on the magnetic field agrees with the theoretical analysis of Refs. [1,2] based on the collective coordinate approach. For shorter junctions we find deviations from the prediction of this analysis. Experimental results and numerical simulations show fairly good agreement.

[1] M. Fistul et al., Physica B **284-288**, 585 (2000)
[2] M. Fistul et al., Phys. Rev. Lett. **91**, 257004 (2003)