Self-heating Effect in Stacks of $Bi_2Sr_2CaCu_2O_{8+x}$ Intrinsic Josephson Junctions

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Poor thermal conductivity in $Bi_2Sr_2CaCu_2O_{8+x}$ is known to cause a serious local overheating problem in the interlayer tunneling spectroscopy on intrinsic Josephson junctions (IJJs) when a high-density bias current is used. The resulting temperature variation due to Joule heating at high bias may cause a spurious effect in the spectroscopic signal. We investigated the heating effect in a stack ('source stack') of IJJs by monitoring the temperature variation of the small bias-resistance in another stack ('detector stack') of IJJs, which is located within a fraction of micrometer from the source stack. Two stacks were thermally coupled by a 100-nm-thick Au electrode. We obtained the local temperature of the source stack for various bias currents over an initial temperature range from 4.2 K to 90 K by monitoring the c-axis quasiparticle tunneling resistance of the detector stack at a constant bias current. The overheating revealed as a back-bending in the current-voltage curve of the source stack was more conspicuous at low base temperatures because of the lower thermal conductivity. This in-situ temperature monitoring technique combined with the digital proportional-integral-derivative control allows one to get rid of spurious effects arising from the overheating. This method can provide the heating-free interlayer tunneling spectroscopy for the pseudogap research in high critical temperature superconductor.

keywords : thermal conductivity, self-heating effect, interlayer tunneling spectroscopy