Shapiro Step Response of Intrinsic Josephson Junctions with High Critical Currents of $(Bi_{1-x}Pb_x)_2Sr_2CaCu_2O_y$

Nurmiza Binti Othman, Gin-ichiro Oya, Michihide Kitamura, and Akinobu Irie

Abstract - We have studied the response of intrinsic Josephson junctions (IJJs) in cross-shaped samples of $(Bi_{1-x}Pb_x)_2Sr_2CaCu_2O_y$ (x = 0.15) with high critical currents I_c at 4.2 K to injection of microwave with frequencies f_{rf} of 2–20 GHz. At the early stage of measurements Josephson vortex flow is induced in the IJJs by supplying high currents to them. After that, by injection of microwave power P to them clear constant voltage steps are successfully observed on their current-voltage characteristics, although their plasma frequency f_{pl} is much higher than f_{rf} and they are not resistively shunted. The constant voltage steps appear so as to satisfy the Josephson frequency-voltage relation and behave like Shapiro steps depending on P. Such behavior of steps is well reproduced by numerical simulations on Shapiro step response of JJs with shunt resistivity which is equal to the Josephson-vortex flow resistivity under microwave injection. Consequently, the observed constant voltage steps may be Shapiro steps out of the IJJs with the Josephson-vortex flow resistivity.

Index Terms - $(Bi_{1-x}Pb_x)_2Sr_2CaCu_2O_y$, high-$T_c$ superconductor, intrinsic Josephson effect, Shapiro step.

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