Numerical Simulation of Self-heating on Interlayer Tunneling Spectroscopy of $Bi_2Sr_2CaCu_2O_{8+x}$

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Large self-heating arises for interlayer-tunneling-spectroscopic measurements on a small $Bi_2Sr_2CaCu_2O_{8+x}$ (Bi-2212) stack structure with lateral dimension of ~3x3 μm^2, due to poor thermal conductivity of Bi-2212. This increases the sample temperature by ~150 K for a bias about 50-70 mV per junction. In this study, we numerically estimate the self-heating around a Bi-2212 sample stack during *I-V* or *dI/dV-V* measurements. We estimate the temperature difference between the sample stack and the thermometer stack, which are assumed to be 0.5 μm apart from each other (this mimics the actual measurement configuration employed in our earlier studies). Our results show that the temperature nonuniformity due to self-heating is negligible (<1 K) along the *c*-axis direction of Bi-2212 including the top Au electrode. On the other hand, the temperature discrepancy between the sample and the thermometer can be as large as ~10 K for the highest bias assumed. Our results indicate that the thermometry using the Bi-2212 thermometry stack does not provide accurate-enough temperature reading of the sample stack. We will present a new in-situ ac thermometry using the Au current-bias electrode itself deposited on top of the sample stack, which may allow genuine temperature measurements of the Bi-2212 sample. Once the thermometry is accomplished accurately the self-heating can be eliminated by using the "heating compensation" technique [1] introduced by us previously, which may enable the genuine tunneling spectroscopic measurements.

[1] Myung-Ho Bae, Jae-Hyun Choi, and Hu-Jong Lee, Applied Physics Letters 86, 232502 (2005).

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