Atomic Structure of the Metal/Superconductor Interface by Atomic-Resolution Z-Contrast Imaging

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Introduction

The new generation probe aberration corrected transmission electron microscopes with scanning attachment (STEM) can easily achieve sub 1Å probe size, i.e. sub-Angstrom resolution, which makes it easier to study the real materials problem at atomic scale both in terms of atomic structures and electronic structures.

Experimental and Discussion

In this report, we will show the atomic structure and electronic structure of the interface between a normal metal and an unconventional perovskite oxide superconductor. Sr$_2$RuO$_4$ is an unconventional spin-triplet superconductor[1], and it is the first perovskite superconductor that shares the same crystal structure as high-$T_c$ superconductors of copper oxides, but without Cu. It has been a subject of active investigations. At about 1.5 K, the value of $T_c$ is unremarkable, but interest was immediately aroused by a possible relationship to the high-$T_c$ cuprate superconductors. It was surprisingly found out that a remarkable enhancement of $T_c$ by a factor of about 2 to reach 3 K in a two-phase composite eutectic system that is made of a single-crystalline matrix of Sr$_2$RuO$_4$ in which microdomains of ruthenium metal are embedded [1]. Figure on the left shows the atomic structure of the Ru/ Sr$_2$RuO$_4$ interface revealed by HAADF STEM imaging. The interface revealed is Sr$_2$RuO$_4$ (100) plane meeting a Ru (0001) plane. It is clearly shown that the Sr$_2$RuO$_4$ terminating plane at the interface that is not a basal (001) plane also terminates at only the Sr atoms, leaving the RuO$_2$ octahedron intact. Figure on the right shows the preliminary results of the EELS from the interface compared with the region from the bulk. Peak B, C, D, E are labeled according to the convention by the X-ray absorption spectroscopy on Sr$_2$RuO$_4$ sample. The comparison of the two spectra shows the fine structure change of the peaks, particularly the D peak height relative to the E peak at the interface. It is known that D peak reflects the bonding of Ru $e_g^*$ and planar oxygen $2p\sigma$, and this peak is sensitive to the bond distortions [2].

References