12-4 Curious Characters of Iron-Based Superconductors
－R&D for Application Based on Their Unique Features－

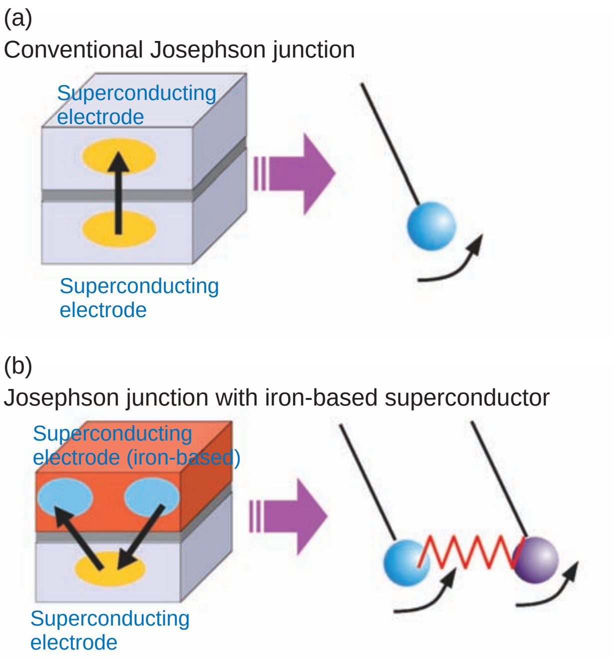

Fig.12-8 Models of Josephson junctions
A conventional Josephson junction is described by motion of a simple pendulum model (a), while a junction with iron-based superconducting materials is described by a coupled pendulum model (b).

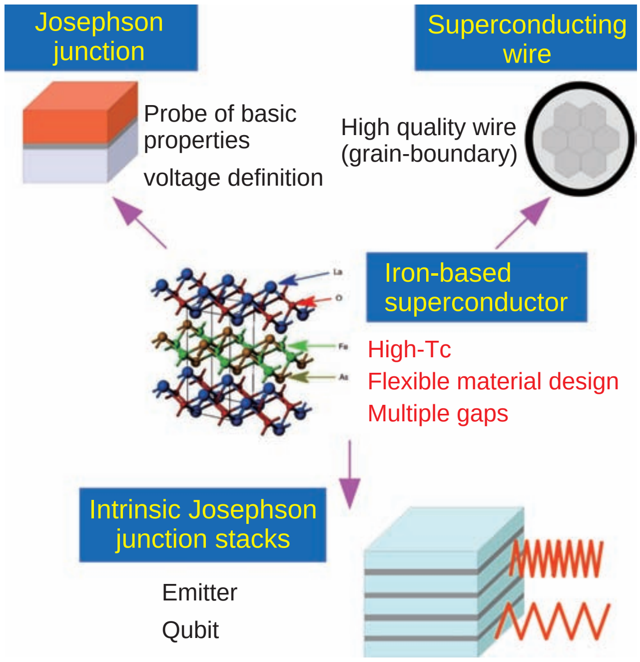

Fig.12-9 Application potential of iron-based superconductors
Various potential applications of iron-based superconducting materials, such as material properties probes, voltage definition, wires, emitters, and qubit.

Superconductivity is one of the most remarkable phenomena in condensed matter systems. A typical behavior is the sudden disappearance of electric resistance below the superconducting transition temperature. Such a property not only brings about transportation with no energy loss but also leads to sensitive detectors and devices much superior to standard ones. Presently, in the nuclear R&D field, potential applications of the superconductors are being intensively studied. In fact, a superconducting coil will be indispensable for a nuclear fusion reactor.

A new superconducting material, an iron-based superconductor was discovered in 2008. This type of a material has a very high transition temperature compared to copper-oxide superconductors and a richly varied chemical composition. One of its most curious features is that multiple (at least three) superconducting gaps coexist, although most existing superconductors have a single gap. Recently, we have been studying the device characteristics originating from their multi-gap feature, focusing on the Josephson junction, which is a typical superconducting device.

First, we directed our attention to the fact that a conventional Josephson junction is theoretically equivalent to the motion of a single pendulum, and the behavior of the superconducting tunneling current is well described by such an elementary dynamical model (Fig.12-8). The present task is to reveal how the conventional description alters when one of the superconducting electrodes is replaced by the iron-based superconductor. We successfully demonstrated that the system is described by coupled oscillators, and went on to predict various electrical and magnetic characteristics of iron-based superconducting devices.

The present contribution provides a theoretical foundation of Josephson junctions with iron-based superconductors. We believe that this study clarifies the essence of iron-based superconductors and will lead to further developments in superconducting engineering (Fig.12-9).

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Reference

Ota, Y. et al., Theory of Heterotic Superconductor-Insulator-Superconductor Josephson Junctions between Single- and Multiple-Gap Superconductors, Physical Review Letters, vol.102, issue 23, 2009, 237003-1－237003-4.