SUMMARY OF Ph.D. DISSERTATION

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Title

Study of tunneling junction by current spectroscopy.

Abstract

To estimate the state of oxidized Al thin film using inelastic electron tunneling (IET) spectroscopy, correspondence of IET spectrum and oxidation state was investigated. The aging effect of tunneling junction and the state of broken down tunneling junction was analyzed using IET spectroscopy.

The inhomogeneous and homogeneous distributions of metallic Al corresponded to asymmetric and symmetric IET spectra, respectively. These junctions showed peaks at ±0.03 V. AlO_x oxidized for 168 h contained no metallic Al, and this junction had no peaks, suggesting that peaks at ±0.03 V originate from metallic Al. An ultra-thin Al film was oxidized in three stages. In stage 1, the Al layer was oxidized at the surface, forming AlO_2. In stage 2, the Al layer became a homogeneous Al_2O_3 barrier. In stage 3, the Al layer became Al_2O_3, and contained no metallic Al.

The aging effect of tunneling resistance by constant voltage stress was independent of the voltage polarity. The lifetime under negative voltage was longer than under positive one. When the applied voltage was positive, the IET spectrum did not change, whereas when it was negative, the asymmetric IET spectrum became symmetric. This indicates that the AlO_x layer became homogeneous due to oxidization of metallic Al in the AlO_x/bottom electrode interface. Because the AlO_x became homogeneous, the lifetime of junction increased.

After electrical breakdown induced both by a ramped voltage stress and by a constant voltage stress, a peak appeared near 0.09 V. t is thought that a conduction level, which is about 0.09 eV higher than the Fermi level, was created in AlO_x by the electrical breakdown. The breakdown is not thought to be due to a simple short circuit caused by a pinhole or the like.