Abstract:
We have fabricated micron-sized tunnel junctions incorporating aluminium oxide barriers treated with a low energy electron bombardment. These junctions show a significantly lower 10 Hz 1/f resistance noise level at 4.2K than junctions which have not been treated. The electron bombardment process thus provides a means for producing low noise, aluminium oxide based Josephson junctions for quantum computing applications.

Summary:
Micron-sized Al/AlOx/Al tunnel junctions are fabricated using standard photolithography, reactive ion etching and ion milling techniques. Junction layers are formed by first thermally depositing an aluminium base electrode layer, followed by room temperature thermal oxidation to form the oxide barrier layer and finally the aluminium top electrode layer. The thickness of the oxide barrier is about 15-20Å. For a subset of junctions, the oxide layer is exposed to low energy (~10-20 eV) electrons prior to the deposition of the top electrode layer. X-ray photoelectron spectroscopy studies show that although the thermally oxidised barrier layer is oxygen deficient, the low energy electron bombardment can drive surface chemisorbed oxygen molecules into the oxide, making it more stoichiometric [1]. This results in an oxide barrier layer with fewer defect states, which have been demonstrated to be a source of 1/f resistance noise in Josephson junctions [2].

The 1/f resistance noise characteristics of the junctions are measured between 4.2K and 300K. At 4.2K, junctions exposed to the electron bombardment exhibit a lower 10 Hz resistance noise level (~1.2 x 10^{-22} m^2/Hz) compared to junctions which were not exposed (~1.3 x 10^{-21} m^2/Hz). The improvement in the noise figure by a factor of ~10 indicates that the low energy electron bombardment method can be used effectively to produce lower noise Josephson junctions based on aluminium oxide tunnel barriers.

References:
• We fabricated micron-sized aluminium oxide tunnel junctions and measured their low frequency noise characteristics between 4.2K and 300K.

• By exposing the aluminium oxide barrier to a low energy electron bombardment before junction fabrication, the low frequency resistance noise in the junction can be significantly reduced.

Figure 1, opposite:
Aluminium oxide tunnel junction 1/f resistance noise figures at 10 Hz measured at temperatures between 4.2K and 300K. At 4.2K, junctions containing an electron bombarded oxide layer (filled circles) show a factor of ~10 reduction in the noise figure compared to junctions whose oxide layer had not been electron bombarded (hollow triangles).