SIS Receiver Development Projects – 2006-2007

ARK 19 Dec 2007

1) 787-950 GHz Receiver Technology Development (with UVML). Success in this will put us in a good position to bid on ALMA Band 10 receivers – either the mixers or the complete cartridges.

2) 385-500 GHz SIS mixer Development (with UVML, funded by ARO). The 385-500 GHz mixer is being developed largely as a half-frequency model of the Band 10 mixer (above). It enables mixer designsto be evaluated using AlN SIS junctions and all-Nb conductors prior to using NbTiN.

3) Balanced and Balanced Sideband-Separating SIS Mixer Development (with ARO, funded by ARO). This project is the next step towards the ultimate low-noise SIS receiver. The goal is a balanced sideband-separating SIS mixer with very low noise and low LO power requirement. Such mixers will be essential for future coherent mm/sub-mm *focal plane and beam forming array* receivers.

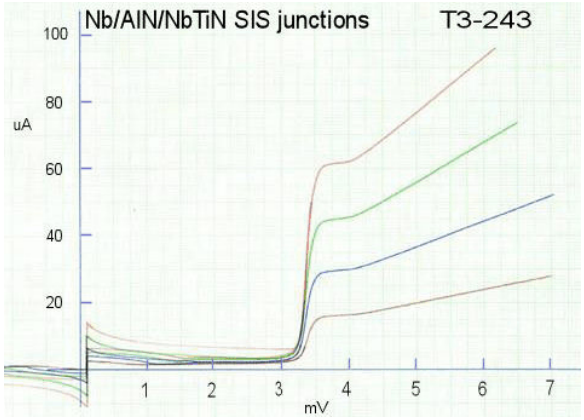
4) Very-Low-Loss Passive Front End Components. To lower the loss of the feed and polarizer or 90-degree hybrid at the input of receivers we are exploring the RF loss of un-plated copper conductors. It appears that high conductivity copper transmission lines and waveguides should be as effective as high-temperature superconductors in cryogenic applications not requiring high-Q resonators (such as interference filters). It is well known that the resistivity of copper decreases by more than an order of magnitude from room temperature to ~30 K. If it is possible to reduce conductor loss in the front end sufficiently, the input loss will be reduced to little more than that of the connectors. An experiment is currently under way to measure the microwave loss of copper, aluminum, and gold-plated copper circuits at room temperature and cold.

Recent results:

A) The University of Virginia Microfabrication Laboratory has successfully fabricated SIS junctions with **AlN** tunnel barriers as required for NbTiN SIS junctions – see figure. Junctions with AlN barriers have been sucessfully made with high critical current densities desirable for high frequency boadband operation. This is a major milestone on the way to advanced NbTiN/insulator/Nb tunnel junctions for frequencies above 700 GHz.

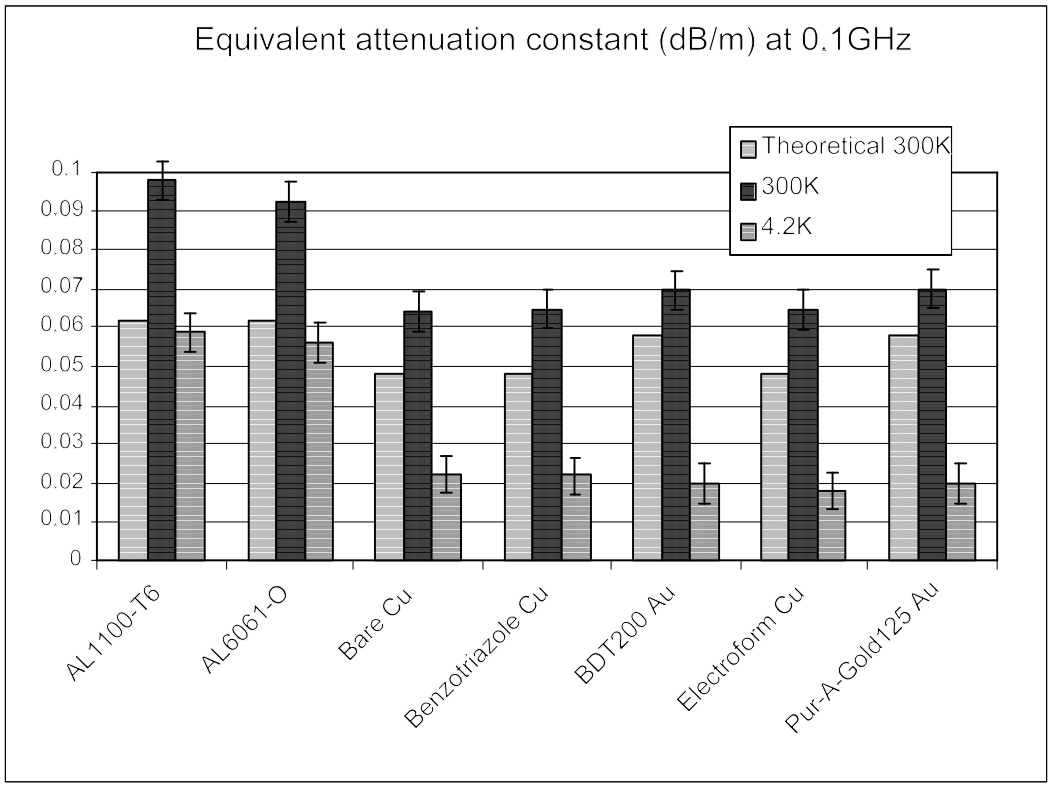
I(V) characteristic of a Nb/Al-AlN/Nb SIS junction with JC = 30,000 A/cm2

B) UVML has successfully made Nb/Al-AlN/**NbTiN** SIS junctions with good quality. The I(V) curves of four junctions of different sizes are shown in the figure. The critical current density Jc is ~5,000 A/cm2, which is lower than we would use for Band 10, but based on his recent success with Nb junctions with AlN barriers (above), we can expect good quality junctions with Jc as high as 30,000 A/cm2 to be practical.



C) In the CDL, the 787-950 GHz SIS mixer design has been started and the design of the 385-500 GHz SIS mixer is almost complete.

D) The loss of several conductors at room temperature and 4 K has been measured as indicated in the figure. Further measurements of plated copper and plated gold conductors, with and without annealing, are planned.



Note: The suffixes of the aluminum types should be interchanged.