TANTALUM HOT-ELECTRON BOLOMETERS FOR LOW-NOISE HETERODYNE RECEIVERS

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During the last few years, the superconducting hot-electron bolometer (HEB) mixer has been rapidly developed for radioastronomy applications at frequencies above 1 THz. HEB receivers are currently under development for instruments on both *Herschel* and *SOFIA*. It can be expected that in the future such systems will be required to provide higher sensitivity (lower receiver noise) and higher intermediate frequency (IF) bandwidth than those of today. They should preferably also be able to operate with lower amounts of local oscillator (LO) power since this simplifies inclusion in tomorrow's space-borne missions.

Theory predicts that the mixer noise of HEBs should scale with the transition temperature (Tc) of the superconducting film [1]. Recent experiments on devices with Tc lower than that of Nb (both Nb with Tc suppressed by a magnetic field, and aluminum [2]) give lower mixer noise temperatures than, Nb bolometers with the full transition temperature. A lower Tc also leads to reduced LO power requirements, but it can also cause saturation problems (especially in high-background applications).

One promising material for lower-Tc diffusion-cooled HEB mixers is tantalum, which has a transition of about 4.4 K in bulk (and about 3K in thin films). In contrast to aluminum, Ta does not suffer from detrimental device-end effects at the S-N interface to the normal metal contacts. Devices made from clean Ta films can have resistances as low as 20 ? /square, which should lead to significant electronic heat conductivities. The lower Tc, the relative absence of end effects and the high heat conductivity should in principle make possible a short (0.2 to 0.5 µm) device with low mixer noise and high intermediate frequency bandwidth (the diffusion constant of Ta should be the same or larger than that of Nb).

Submicron tantalum bolometers (length=0.4 µm, width = 0.2 µm) have recently been fabricated at JPL from films deposited on a 1.5 nm Nb seed layer, which nucleates the desired bcc-phase. Transitions up to 2.3 K, with transition widths of less than 0.2 K have been achieved. The resistance of these devices is about 36 ? per square, with a supercurrent of about 40 µA. These devices do not exhibit Shapiro steps when illuminated at frequencies of 1-to-18 GHz, which shows that they are indeed bolometers and not weak links. At high bias currents the thermal noise generated by the devices increases in proportion to the square root of the applied DC heating, which is consistent with a diffusion-cooling mechanism. In the full presentation we will discuss the most recent results from these Ta HEBs, including measurements of device speed that are currently underway.

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[1] Karasik et al., IEEE Trans. Appl. Superconductivity, Vol.9, No.2, June 1999
[2] I. Siddiqi et al., IEEE Trans. Appl. Superconductivity, Vol.11, No.1, March 2001