Analysis of the Influence of Current Density j_c and DC-Quality Q on Mixer Performance around 700 GHz for more than 50 measured SIS-Mixers

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For the development of the band 2 mixers (636-802 GHz) for the HIFI instrument on the Herschel Space Observatory[2] the RF-performance of more than 50 mixers with $Nb/Al_2O_3/Nb$-junctions fabricated at KOSMA have been characterized. Based on the DC-characteristics and RF-performance the choice of the best devices for the flight mixers has been made. According to the results the design approach of the mixers is revisited.

During the SIS-device development process the device parameters (gap-voltage V_{Gap}, current density j_c, dc-quality $Q = R(2\,\mathrm{mV})/R_N$, strip-line conductivity σ and accuracy of junction-area) have been optimized. Because of the Nb-gap at 700 GHz the power losses of the $NbTiN/SiO_2/Nb$ micro strip matching circuit are much lower in the lower frequency region (5%) than in the upper frequency band (33%). In addition to these micro strip losses the parameters j_c and Q show the strongest impact on the mixer performance. These two parameters can not be optimized independently since a higher j_c implies a thinner barrier and lower Q.

To evaluate the trade-off for an optimum combination of j_c and Q the noise performance for more than 50 experimental I-V-curves with the FM-design embedding impedance is calculated from Tucker's theory for different values of j_c. The reduction in receiver noise caused by an improved Q becomes small for values of $Q > 8-10$. The reduction in receiver noise caused by a higher j_c is much larger in the upper frequency band with high micro strip losses. The calculations together with a fabrication-dependent relation of realizable j_c and Q can be used as a guideline for optimum design parameter for j_c.

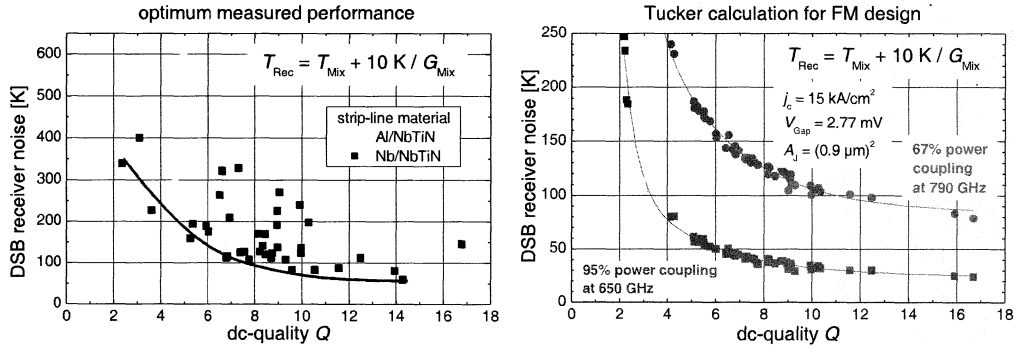

Figure 1: *Receiver performance dependence on junction DC-quality Q. Left: measured optimum performance of mixers in HIFI band 2. Right: calculated receiver noise (Tucker) for measured I-V-curves as function of DC-quality Q. The data show the results for two frequency points of the FM-design embedding impedance.*

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