Device Technology for SIS Mixers in the 1 – 1.5 THz Band

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Superconductor–insulator–superconductor (SIS) mixers have been developed to operate in the THz regime with the highest frequency reported so far being 1.2 THz [1]. Best results are obtained by using low–loss normal metal tuning circuits and junctions with extremely high current density.

We are developing a technology to fabricate SIS mixers which should be capable to give low noise performance well abve 1 THz. We follow up on earlier work [2,3] where the embedding circuit is an Al / SiO_2 / Al micro strip. For the ground plane of the micro strip we use single crystalline Al films on Si (111) substrates deposited in a molecular beam epitaxy system. Apart from their high conductivity, $\sigma_{4\,\mathrm{K}} > 5 \cdot 10^8/(\Omega\,\mathrm{m})$, implying low rf losses, these Al films provide a very smooth surface for the subsequent growth of the SIS trilayer. We find that this is an important issue for making high quality junctions in terms of a low leakage insulating barrier. The junctions are based on Nb / AlN / NbTiN trilayers and have a sum gap voltage of $V_{\mathrm{gap}} = 3.5$ mV, setting the maximum operating frequency to $1.7 \cdot e\,V_{\mathrm{gap}}\,/\,h \simeq 1.5$ THz. Lithographic definition of the junction makes use of direct e-beam writing and dry etching techniques. The junction area can be made as small as 0.3 $\mu\mathrm{m}^2$, current densities are 20 – 30 $\mathrm{kA/cm}^2$ with the subgap to normal resistance ratio ≥ 10.

RF absorption losses in high quality Al are not expected to increase strongly with frequency making this type of circuit suitable for THz SIS receivers. We discuss the possibility to use higher gap junctions based on NbTiN / AlN / NbTiN which could operate up to ~ 2 THz.

References

[1] Karpov et al, these proceedings
[2] Bin et al, Appl. Phys. Lett. **68** (12) 1996
[3] Gao et al, Proceedings 7th ISSTT 1996