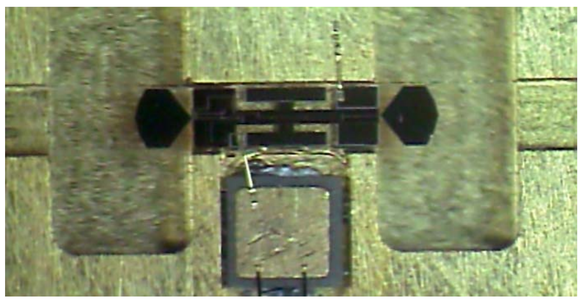
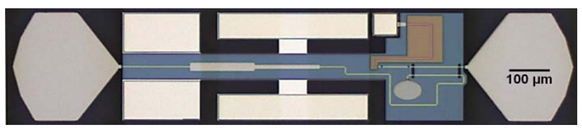
Advanced technologies for heterodyne radio astronomy instrumentation

Group for Advanced Receiver Development, Chalmers University of Technology (Sweden)

Thin Film Technology for SIS Mixers

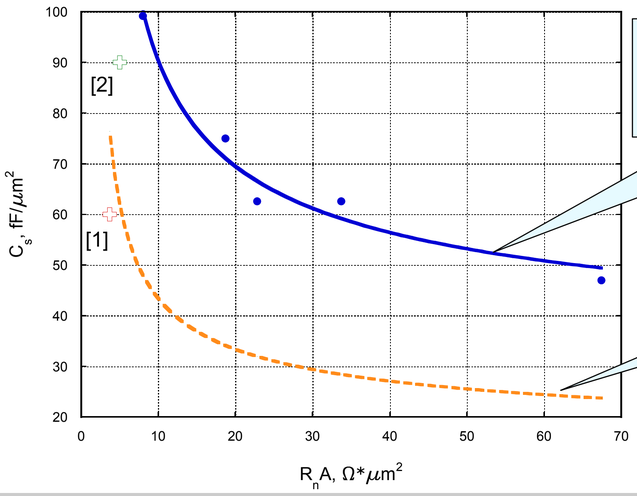




ALMA Band 5 SIS mixer chip (*lower image*) mounted in the mixer end-piece (*upper image*

SIS processing summary

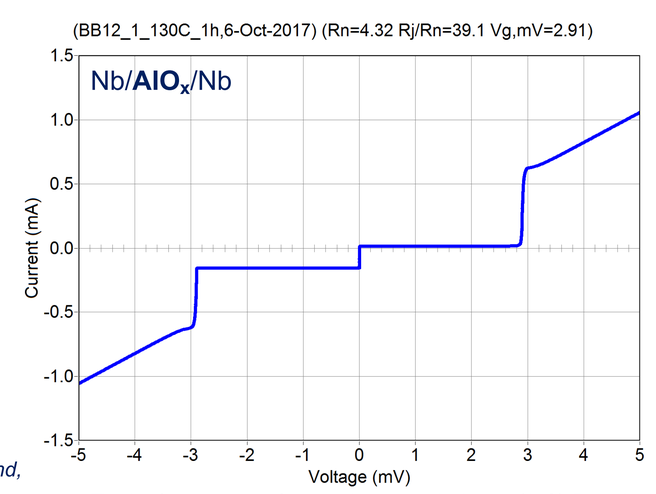
- Junctions:
  - junction size -- down to 2µm^2;
  - Nb/**AlO$_x$**/Nb junctions:
    - ✓ R_nA -- down to 15 Ω·µm^2;
    - ✓ R_j/R_n ratio -- above 20;
  - (*new*) Nb/**AlN**/Nb junctions:
    - ✓ R_nA -- down to 10 Ω·µm^2;
    - ✓ R_j/R_n ratio -- above 20;
- Resistors:
  in the range 1…50Ω/□;
- Nb tuning circuitry:
  - strip width -- down to 3µm;
  - strip thickness -- up to 0.4µm

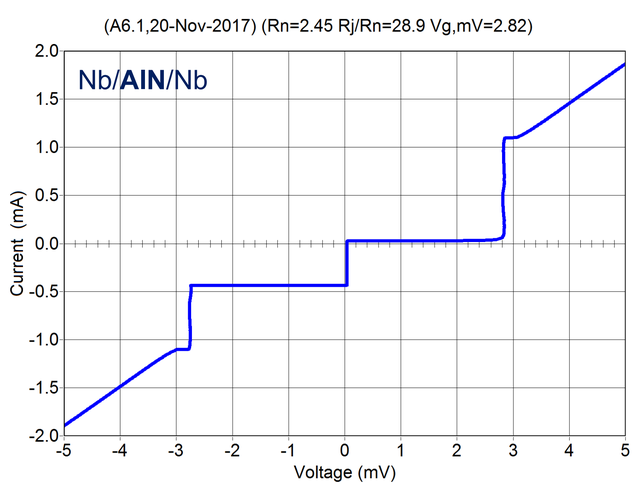


C_s *vs* R_nA dependence for Nb/**AlO$_x$**/Nb junctions (*Aghdam P.Y., IEEE Trans. On THz Sci.Tech, 2017, v.7, No.5, p. 586-592*). Fitting curve $C_s = 210/ln(R_nA)$

C_s *vs* R_nA prediction for Nb/**AlN**/Nb junctions based on the data from [1] and [2]: $C_s = 100/ln(R_nA)$

[1] Lodewijk C.F.J., *IEEE Trans. On Appl. Supercond, 2009, v. 19, No.3, p. 395 – 399*
[2] Kojima T., *IEEE Trans. on THz Sci.Tech, 2017, v.7, No.6, p. 694-703*

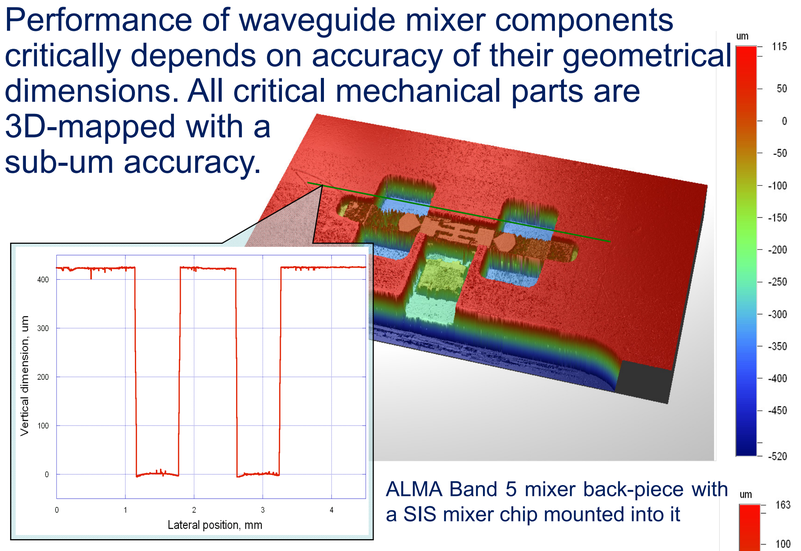




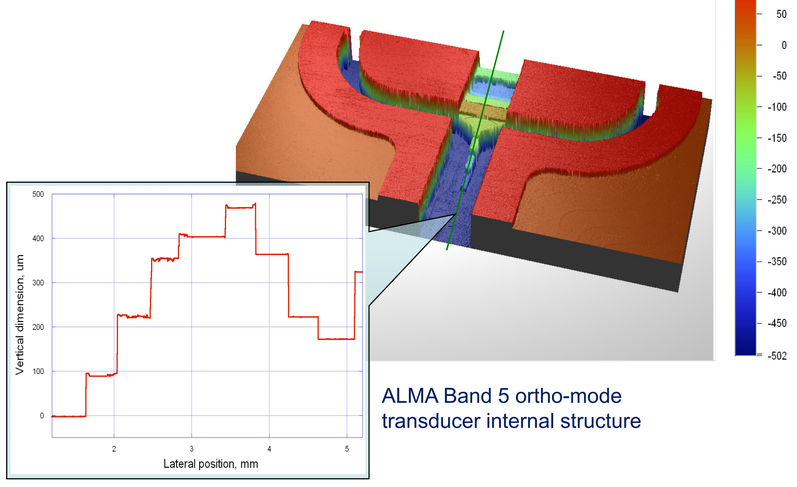
Typical current-voltage characteristics: (*left*) Band5 Nb/AlO$_x$/Nb twin junction, 3 µm^2 each, ca. 25 Ω·µm^2 ; (*right*) Nb/AlN/Nb twin junction, 3 µm^2 each, ca. 15 Ω·µm^2

3D Characterization of Mechanical Parts

Performance of waveguide mixer components critically depends on accuracy of their geometrical dimensions. All critical mechanical parts are 3D-mapped with a sub-um accuracy.



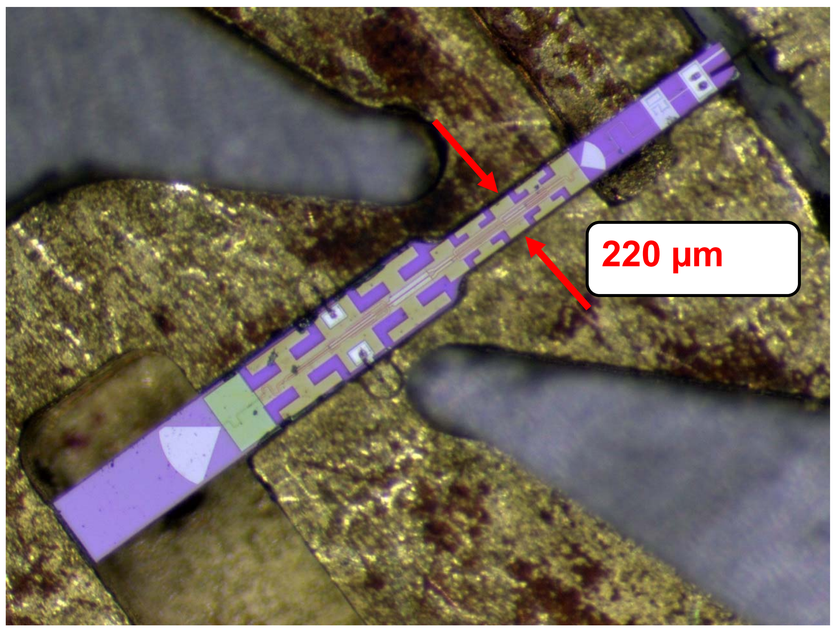
ALMA Band 5 mixer back-piece with a SIS mixer chip mounted into it



ALMA Band 5 ortho-mode transducer internal structure

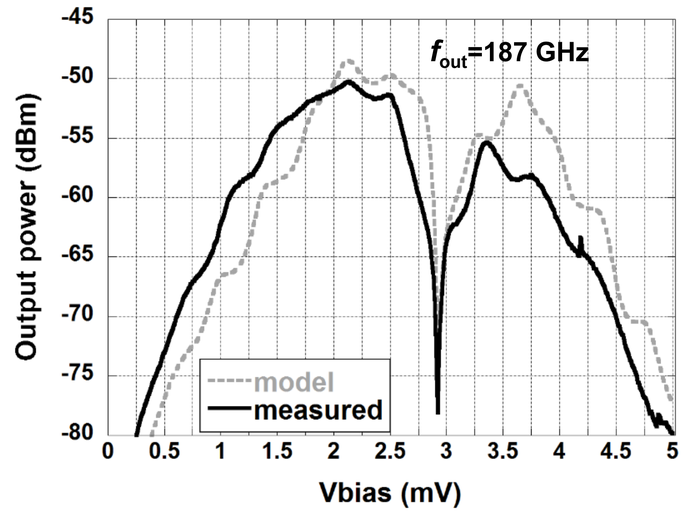
Superconducting frequency multiplier

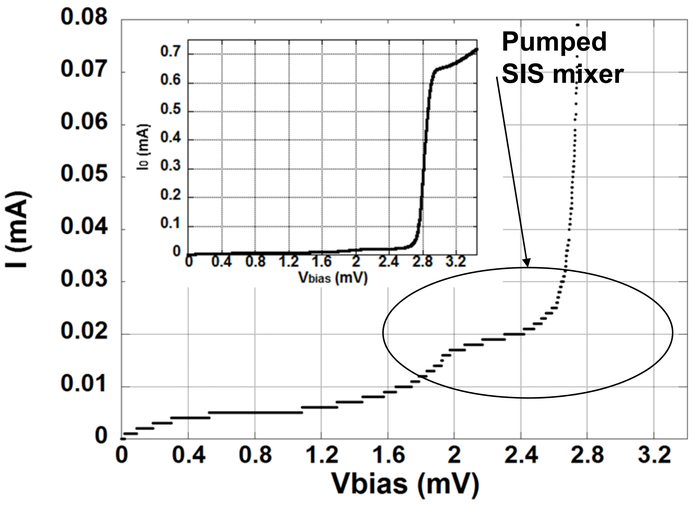
based on distributed SIS junction



Multiplier chip contains input and output waveguide to microstrip transitions, impedance transformers, input and output BP filters, power dividers and two distributed SIS junctions.

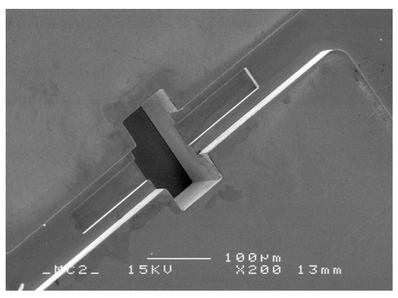
- The multiplication efficiency of the distributed SIS junction is 15-30 %
- The measured peak power of the generated signal at different frequencies is approximately constant over 10% fractional bandwidth.
- The frequency is able to pump an SIS mixer



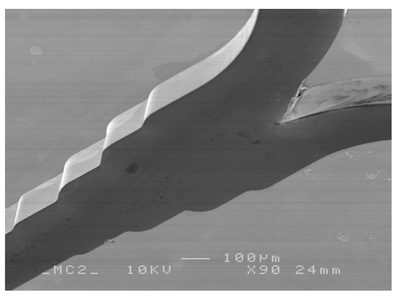


Future: THz Waveguide Technology

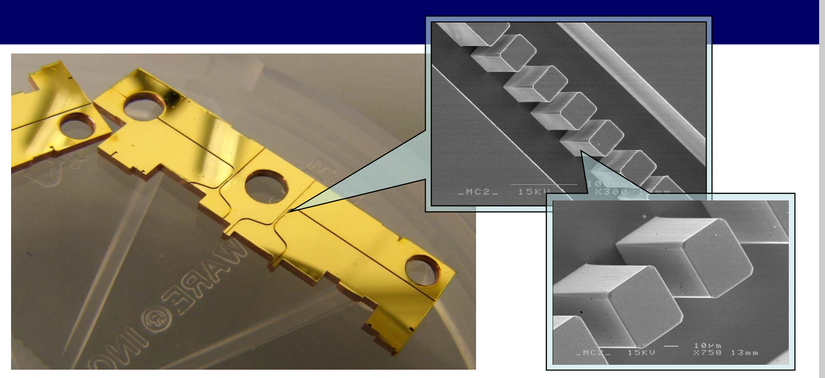
GARD pioneered and further develops micro-machining waveguide technology allowing submicron definition and surface quality (Rq ≤ 30nm) of any complex structure within up to 3-layer technology.
The technology has been successfully demonstrated over a wide frequency range: 385-500 GHz, 600-750 GHz and 1.29-1.35 THz. We see the potential for using this technology for up to 6 THz.



APEX Band T2 1.32 THz Back-piece



APEX Band3 385-500 GHz Mixer block



APEX T2 Waveguide 3dB coupler at 1.32 THz