Reliability assessment of GaAs and InP THz mixers and frequency multipliers fabricated on 3" wafers

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***Abstract*—We report on the developments in this two-year European Space Agency funded project that aims at performing a preliminary reliability study of 300 GHz InP heterostructure barrier varactor diode multipliers and 1.2 THz GaAs Schottky diode mixers. Fabrication of the monolithically integrated circuits will be done on 3” wafers using established III-V processing. The reliability tests that will be performed include thermal and electrical step-stress studies, as well as shock, humidity and accelerated lifetime tests. We will present results and analysis of these experiments.**

Summary

THz sources and detectors have in the recent decade found their way into applications in fields such as security imaging, telecommunications and bio sensing. But radio-astronomy has been the traditional application for mm-wave and THz devices. Several space bound exploratory missions have carried instrumentation operating in this frequency range. Whether deployed to orbit earth or to explore outer space, it is vital for the mission success that the instrumentation is highly reliable, i.e can perform as expected throughout its planned lifetime. It is therefore essential to conduct reliability tests on device/component level to ensure projected performance in future missions.

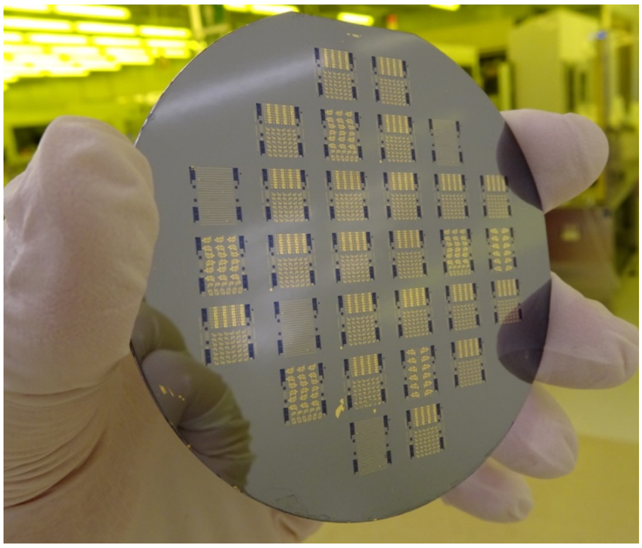
This work describes the preliminary reliability testing of 300 GHz heterostructure barrier varactor diode frequency multipliers [1] and 1200 GHz Schottky diode mixers [2] fabricated on 3” wafers.

Initial electrical and thermal step-stress tests will help us outline the maximum possible temperature, current, voltage or RF bias that a component can endure. This is executed by raising the applied voltage bias for instance on a device, at 24-hour steps, and then measuring the devices electrical characteristic (i.e current-voltage, capacitance-voltage, S-parameter). The results from the step-stress tests will be used as boundary conditions for the accelerated lifetime tests.

Accelerated lifetime tests will be used to estimate the longevity of the THz circuits. Because of the exponential dependence on temperature of the physical and chemical changes in the device material and structure it is possible to stress the devices/circuits by operating at elevated temperatures. In this way, the components can be driven to failure in much shorter time (<< 1 year) than their expected lifetime at room temperature. By doing this at several elevated temperatures we can extrapolate the device lifetime at corresponding realistic circumstances. Within this project we will study storage accelerated lifetime, DC bias accelerated lifetime, and RF accelerated lifetime. In addition, we will investigate the influence of humidity, thermal cycling and mechanical shock on the devices/circuits and module packaging.

The complexity, functionality and integration level of today's THz circuits render them of millimeter size, thus requiring large wafer fabrication to reduce cost and open up for their use in various low- to mid- volume applications.

By scaling THz monolithically integrated circuits fabrication to 3” wafers and reliability testing these, we aim at priming THz sources and detectors for future applications and high volume supply.



A 3” GaAs wafer divided into 10x9 mm^2 chips intended for reliability testing.

[1] J. Vukusic, T. Bryllert, Ø. Olsen, J. Hanning, and J. Stake, “Monolithic HBV-Based 282-GHz Tripler With 31-mW Output Power,” *IEEE El Dev Lett*, vol. 33, no. 6, pp. 800–802, Jun. 2012

[2] P. Sobis, V. Drakinskiy, N. Wadefalk, P. Å. Nilsson, A. Hammar, D. Nyberg, A. Emrich, H. Zhao, T. Bryllert, A. Y. Tang, J. Schleeh, J. Grahn, and J. Stake, “SWI 1200/600 GHz Highly Integrated Receiver Front-Ends”, Proceedings of the 36th ESA Antenna Workshop on Antennas and RF Systems for Space Science, ESA/ESTEC, Noordwijk, The Netherlands, October 2015

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