

Production of ALMA Band 2 Cryogenic 1st Stage LNA

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Abstract— We report on the ongoing production and qualification of the cryogenic 1st stage low noise amplifiers for the ALMA Band 2 receiver. The RF performance results for the first production batches are presented and are evaluated against the technical specifications. The measurement results so far agree with the successful pre-production run in 2022. In particular, the state-of-the-art noise performance over the extended W-band (67 GHz – 116 GHz) is achieved.

Keywords—Cryogenic, high-electron-mobility transistor (HEMT), low-noise amplifier (LNA), metamorphic HEMT (mHEMT), millimeter wave (mmW), monolithic microwave integrated circuit (MMIC), radio astronomy, W-band.

I. INTRODUCTION

The European Southern Observatory (ESO) has awarded the MPIfR/Fraunhofer IAF consortium the production of the cryogenic 1st stage LNA units for the upcoming ALMA Band 2 receivers.

Decisive was the successful demonstration of repeatable state-of-the-art performance for a small series pre-production run of LNA units in a production-like environment [1].

Band 2 covers the entire atmospheric window in an extended W-Band from 67 GHz – 116 GHz. Complying to the specifications, in particular the noise performance, over this large frequency range sets challenges not only in the design and fabrication of the LNA, but also the measurement instrumentation required for qualification.

II. LNA PRODUCTION

The cryogenic LNA has been adapted according to the envelope set by ESO's ICD with WR10 waveguide interface for the RF and an 9-pin socket female Omnetics Bi-lobe Nano-D type connector for DC. The LNA is of traditional E-plane split-block design with fused silica substrate waveguide probes at input and output. All components are populated into the lower half (Fig. 1). For the housing all precision machining is performed by the mechanical workshop at the MPIfR, recently upgraded with a Kern Micro HD featuring 5-axis as well as batch processing capabilities. The housing parts are likewise gold plated in-house to established recipe.

A production wafer with the ultra-low noise MMIC using 50-nm gate length metamorphic HEMT (mHEMT) technology is fabricated at Fraunhofer IAF. Here the active device layers are

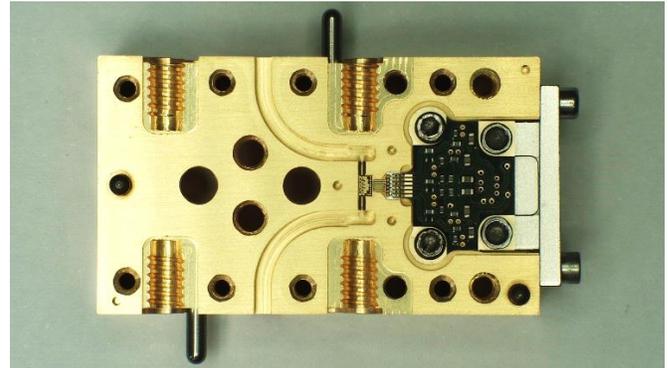


Fig. 1. View into bottom split-block half of one of the ALMA Band 2 production LNA. RF input into the WR10 waveguide is from the top and RF output to the bottom side. The LNA is biased through a Nano-D connector on the right side according to the ICD set by ESO. The depicted lateral dimensions of the split-block are 32.5 mm x 18.92 mm.

grown on GaAs substrates by means of a metamorphic buffer. This technology has matured over the recent years to provide state-of-the-art cryogenic noise performance, concluding in a benchmark W-band LNA design that is basis of our ALMA Band 2 LNA contribution [2].

III. QUALIFICATION

We report on the current status of LNA production and qualification with measurement results. We will detail on the newly developed semi-automated cryogenic measurement setup that features dual measurement capability for S-parameter and noise power based measurements. A custom cryostat employs WR10 waveguide feedthroughs with sliding seals to allow for cryogenic S-parameter calibration. In order to minimize vibrations and ensure quick turnaround of the time-consuming cooling cycles a pulse tuber cooler is employed.

REFERENCES

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