THz POWER AMPLIFIER DEVELOPMENT AT NORTHROP GRUMMAN*

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Northrop Grumman Electronic Systems is developing compact, efficient amplifiers above 100 GHz as part of the DARPA High Frequency Integrated Vacuum Electronics (HiFIVE) and THz Electronics (THzE) programs. For HiFIVE, key sub-components are being demonstrated for a compact 100 W amplifier operating at 220 GHz including a low attenuation folded waveguide (FWG) circuit and a high aspect ratio beamstick with a 750 A/cm$_2$ electron beam propagating through a FWG circuit at a 95% transmission efficiency. The THzE program is developing a high duty amplifier producing 100 mW of RF power at 670 GHz. Both HiFIVE and THzE programs rely upon robust FWG circuits where a TE$_{10}$ mode propagates through a serpentine, rectangular waveguide as the electron beam travels through a beam hole along the axis of the circuit. The FWG slows the RF phase velocity relative to the electron beam, enabling synchronous interaction and net gain.

Above 100 GHz, dimensional tolerances, surface finish, and alignment of the FWG structures require precision micromachining and integration techniques to be used in the assembly of the amplifier. The FWG circuits are fabricated by either DRIE or UV/SU-8 LIGA microfabrication.

The 220 GHz, 100W HiFIVE amplifier is based on five coupled FWG circuits, each with its own beamlet. Micromachined couplers split the input drive signal into each FWG circuit and recombine the amplified signals at the output into a single waveguide with minimal reflections and phase errors. The small signal gain is >30 dB; the input for Psat is <50 mW. FWG circuits have been fabricated by a DRIE process on SOI wafers with a waveguide depth variation was less than ±0.5 μm. This is consistent with minimal phase errors and a power combining efficiency >90%. LIGA-produced solid Cu FWG circuits are also being evaluated. The beamstick to demonstrate transmission of a linear array of 25 circular beamlets uses a rectangular-bore, permanent magnet assembly to focus and confine the beams. The planar magnet has a 9.6 kG peak field with low (<30 G) transverse fields in the beam transmission region.

The THzE 670 GHz amplifier is a single FWG device designed to have and RF output of 100 mW, a small signal gain of 22 dB, and a PAE of 0.98%. Presently, a quasi-optical approach based on free space transmission is planned for the I/O networks.

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