



SUCCESS STORY

TOPIC NUMBER: N121-046

SBIR INVESTMENT: \$879,946

PHASE III FUNDING: \$949,498



SPATIALLY DISTRIBUTED ELECTRON BEAM TECHNOLOGY FOR MILLIMETER-WAVE AMPLIFIERS

This multibeam electron gun is an enabling technology for a new class of compact, high power, broad bandwidth, efficient, millimeter-wave amplifiers for platform self-protection.

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THE CHALLENGE

There is a continual need to improve the power and bandwidth capabilities of millimeter-wave amplifiers in a compact form factor to address emerging millimeter-wave anti-ship missile threats. For fielded systems, in addition to the amplifier compact form factor requirement, the beam voltage for such amplifiers must be maintained at a relatively low voltage to ensure that the accompanying power modulators are also consistent with the small form factor specification. To compensate for the lower beam voltage, higher beam current is an absolute requirement to achieve the necessary radio frequency (RF) power and bandwidth for the evolving needs.

THE TECHNOLOGY

The multibeam amplifier approach provides a solution to the higher beam current requirement. The multibeam electron gun and associated light-weight planar magnet form the basis for Beam-Wave Research Inc.'s (BWRI's) novel multibeam cascaded traveling-wave tube (TWT) concept for RF power generation. The cascaded-TWT serial arrangement provides higher RF power and efficiency than power-combining TWTs with comparable electron beam power. The serial arrangement together with the gun individual beam switching capability also provide a means to vary RF power level via beam switching while maintaining efficiency.

THE TRANSITION

The multibeam electron gun technology was adopted for the MMW embarkable prototype system (MEPS) program under Office of Naval Research sponsorship. An additional investment of \$560K was provided to BWRI by the U.S. Naval Research Laboratory (NRL) via contract N00173-12-C-2026 for this effort. The developed electron gun under this SBIR was fully integrated into a MEPS high-power broadband amplifier, and the amplifier was fully demonstrated in October 2017. This success resulted in a Phase III contract with NRL, contract N00173-18-C-2013 with a contract ceiling of \$3,129,354. The technology was also

adopted by the Defense Advanced Research Projected Agency (DARPA) for the High-power Amplifier using Vacuum electronics for Overmatch Capability (HAVOC) Program. Under this program, BWRI performed amplifier designs and tests as a subcontractor under DARPA's prime contract with Communications and Power Industries, LLC. Under this effort, an additional investment of \$800K is directly attributable to the technology developed under the SBIR program. The multibeam amplifier successfully developed under this DARPA effort is currently being prepared for further testing for potential system insertion.

THE NAVAL BENEFIT

The technology is now fully tested and demonstrated as a viable approach to extend both the power and bandwidth performance of vacuum electronics amplifiers in a compact package. This successful demonstration establishes the technological foundation for advanced amplifiers to meet the evolving needs of the battle space, in general, and to provide enhanced attack capabilities for system self-protection and to address emerging threats in electronic warfare in particular.

THE FUTURE

As the advanced amplifier based on the multibeam technology is being prepared for potential system insertion, there will be opportunity for further development once the system integration is successfully demonstrated. Moreover, the multibeam technology developed under this SBIR program is scalable to other frequencies including the upper millimeter-wave frequencies. Thus, the technology developed under this SBIR program is also adaptable for future development to meet the ever-evolving electromagnetic battle space needs.