NRL BAA Announcement #68-09-01

RF VACUUM ELECTRONICS

The Vacuum Electronics Branch (Code 6840) of the Naval Research Laboratory (NRL) is seeking proposals for innovative technology base development in the broad area of vacuum electronics. Areas of interest include, but are not limited to: (1) advanced high power millimeter-wave amplifiers suitable for radar electronic warfare applications and high data rate communications; (2) the microwave or millimeter-wave power module (MPM) consisting of a solid-state driver, a vacuum electronics power booster, and integrated power conditioning; (3) technologies and techniques to reduce life cycle cost and improve overall reliability of vacuum electronic devices now used or projected for use in U.S. military systems; (4) software modules to support an advanced computational environment for the computer-aided design of microwave and millimeter-wave power vacuum electron devices; (5) supporting technology to advance RF vacuum electronics; (6) advanced emitter technology; and (7) Sheet beam and Multiple Beam Amplifiers. Each area is briefly described below:

(1) High power millimeter-wave amplifiers. The overall goal of this area is to develop the technology base required for advanced high-performance millimeter wave amplifiers suitable for radar, communications and electronic warfare applications. Proposals detailing device concepts relating to the development of compact, efficient vacuum electronic amplifiers operating in the millimeter wave bands (30-300 GHz) and in the submillimeter wave band (300GHz – 1 THz), at peak power levels from 1 W to hundreds of kilowatts, and average power levels of 1 W to tens of kilowatts. Devices should be capable of operation with instantaneous fractional bandwidths of 1% to 20% or higher. Topics of interest include, but are not limited to, (a) innovative high power device concepts using both slow-wave and fast-wave approaches; (b) advanced high-power electron optics and millimeter wave components technology; (c) compact, moderate average power (100 W typical) millimeter wave technology based on spatially distributed electron beams; and (d) innovative application of micro-fabrication techniques to support the development of devices based on sheet electron beams.

(2) Microwave and millimeter-wave power modules, consisting of a solid-state driver, a vacuum electronics power booster, and integrated power conditioning, will find near-term applications in many military and civil systems, including electronic decoys, phased arrays, and high-data-rate communications. Proposals are encouraged under this solicitation that address topics such as (a) improved magnetics to provide high- quality

high-perveance electron beams within module cross-section and weight constraints; (b) improved beam-wave interactions and depressed-collector designs to enhance power booster efficiencies; (c) innovative waste heat removal designs for a dimensionally-constrained MPM; (d) improved solid-state amplifier performance at high-junction temperatures; (e) novel power conditioning schemes to provide spectral purity for radar applications; (f) development of low-loss passive components and devices to minimize overall system losses; (g) improved power conditioning components such as high voltage diodes and capacitors suitable for high-density power conversion; (h) three-dimensional fully-electromagnetic computer modeling; and (i) innovative approaches to developing MPM architectures leading to low unit acquisition costs, (j) innovative power extraction schemes capable of providing small cross-sectional power modules for m X n array applications.

(3) Designing for low-cost consists of innovative design for fabrication in which critical design elements are identified and novel solutions are offered in order to minimize cost, supported with manufacturing analysis as evidence. DoD microwave power tube procurements have traditionally been low-volume runs of limited duration; production of power tubes for certain high-volume applications, such as decoys, is currently too costly. Proposals detailing concepts consistent with these area objectives that are aimed at decoupling unit cost from production volume are encouraged under this solicitation.

(4) The physics- based CAD program is focused on the development of advanced design and simulation capabilities of vacuum electronic devices.

The trade-off consideration used in designing vacuum electron devices strongly depends on the application of the particular device and on the availability of design tools. The Physics Based CAD program requires both the development of general state-of-the-art computational design codes and validation of these codes. The numerical tools should address the electromagnetic, electron beam wave interaction, thermal and mechanical issues and the development of device specific electron gun/collector, large signal and stability analysis design codes. The devices of interest include, but are not limited to: helix and coupled-cavity TWT's, extended interaction klystrons, sheet beam amplifiers, multiple-beam klystrons and gyrodevices. The design tools can use steady state or time-dependent models focusing on one-dimensional, two-dimensional or three-dimensional aspects of the problem. In concert, within the design methodology framework, the design tools should be capable of optimizing the performance of the device by maximizing the efficiency, gain, linearity, and bandwidth and minimizing the noise.

(5) Supporting Technology encompasses the development of materials and technologies that can potentially benefit broad classes of vacuum power amplifiers and oscillators. Proposals that detail innovations and breakthroughs in any one of a variety of technical areas in this context are encouraged. Technical areas include, but are not limited to: (a) innovative cooling techniques for both vacuum and solid state devices; (b) innovative materials research for vacuum power devices, including mechanical and

electromagnetic characterization, modeling, and development of materials, such as - high thermal conductivity insulators, BeO replacement materials, materials with tailored electromagnetic losses; (c) mass- and volume-efficient magnetic materials and magnetic structures to support compact, fieldable systems; and (d) development of micromachining techniques applicable to the fabrication of the electromagnetic circuits used in MMW and SMM vacuum electron devices .

(6) Advanced emitter technology covers both established and evolving electron sources relevant to RF vacuum electronic devices. In most cases high current density, long lifetime, and superior robustness are desired. In specific situations cathodes compatible with insertion into meso-scale and micro-scale electron devices are required. Cathodes suitable for multiple beam and sheet beam devices are of particular interest. Proposals include but are not limited to the following areas: (a) thermionic sources including improved work function-reducing mechanisms allowing longer lifetime and improved uniformity; (b) field emitter arrays including means of regulating the emission at individual sites, means of scaling the total emission current with area, and having moderate to high current density; (d) semiconductor materials having properties suitable for creating sources requiring low or negative electron affinity (e) materials and systems required for photoemitters; (f) cathodes and secondary emitter materials for improved crossed field devices; (g) improved collector design and materials, including methods to suppress secondary electron emission. Proposals that detail breakthroughs and innovations in the materials development and/or cathode design in any of the above areas are encouraged.

(7) Sheet Beam and Multiple Beam Amplifiers - The overall goal of this activity is to develop the technology base required for spatially distributed electron beam high-performance amplifiers suitable for radar, communications and electronic warfare applications. Proposals detailing device concepts relating to the development of compact, light weight, low noise, efficient vacuum electronic amplifiers operating in the range of frequencies from L-band to G-band at peak power levels from 10W to hundreds of kilowatts, and average power levels of 1W to tens of kilowatts. Devices should be capable of operation with fractional instantaneous bandwidths of 1% to 20% or higher. Topics of interest include, but are not limited to, (a) innovative high power device concepts; (b) advanced high-power electron optics for the electron guns and/or multistage depressed collectors; (c) innovative high current density cathodes for long life; (d) design methodology for low manufacturing cost.

Address White Papers (WP) to Code 6840, e-mail, or telephone (202) 404-1453. Allow one month before requesting confirmation of receipt of WP, if confirmation is desired. Substantive contact should not take place prior to evaluation of a WP by NRL. If necessary, NRL will initiate substantive contact.