Phase 2 Project Summary

Firm: ODIS, Inc.
Contract Number: NNX12CA19C
Project Title: Optoelectronic Infrastructure for RF-Optical Arrays

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)

The innovation is a new technology platform to integrate optical and electronic devices. It provides better speed and power reduction than state-of-the-art CMOS and simultaneously all known optical devices as integrated devices. The technology is applied to the RF-optical array problem. Optical distribution techniques are used to deliver modulated RF to each element by optical waveguide. True time delay for beam steering is provided with slow light devices at each element. The coupling coefficient is controlled by refractive index through voltage. Overall voltage control of the main lobe direction is thus achieved. The optical signal passes through an optical amplifier and is converted to RF in a traveling wave photodetector. The receive signals modulate a cw laser at each element with the inverse time delay applied. Within the RF array an optical beam is generated with a 2D VCSEL array. VCSEL beam steering is achieved in the far field by controlling the VCSEL bias current across the array in x and y directions. The VCSELs are used as detectors to collect the return signals. This is the first truly optoelectronically controlled phased array to be devised and has great potential for scaling well into the mmw region

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)
The technical objectives can be summarized
1.Develop the POET epitaxy and the fabrication technique to produce the VCSEL both as a HFET diode laser and as the thyristor. This involves debugging the top mirror deposition, the bottom mirror oxidation and the ion implant for current steering
2.Perform a 2D analysis of the beam formation in the far field of an array of VCSELs with arbitrary optical apertures and spacing. Show that the array is anti-guided for best performance with a main lobe and two sidelobes. Show that the beam may be steered in the x and y directions by varying the current drive linearly to the VCSELs in the desired direction. Then showed that at least 5 degrees of steering may be obtained.
3.Develop the technology fabrication to produce the in-plane optical devices for the transfer and amplification of RF modulated optical signals and the high speed photodetector as a waveguide device to launch RF data at the antenna
4.Develop the microresonator devices with weak coupling to a straight waveguide required to implement the true time delay for the RF signals.
5.Develop the high speed electronic technology in the form of nHFETs and pHFETs to realize all control functions

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

The POET platform was moved forwards. The nHFET and the pHFET were realized as a complementary pair and operated as a ring oscillator. It was determined that the pHFET was slow because of the large capacitance between gate and source and a technique using oxygen implants was devised to solve this problem. The devices were scaled to 100nm and it was found that a new contact technique was required to eliminate the short channel effect and the drain induced barrier lowering. Also lift-off had to be eliminated as unsuitable for production. A new metallurgy was devised. The laser was fabricated to operate cw by correcting both top and bottom mirrors and achieving the correct ion implant parameters for current steering. It was found that equal numbers of wells at each interface are necessary to obtain low threshold current. A new approach to the epitaxial structure was devised to enable a translation of the growth to long wavelength and extremely high performance transistors due essentially to high In content channels. Finally the approach to build spot size converters for low insertion loss coupling was determined as well as the fabrication for in-plane resonators and whispering gallery mode resonators.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)
The NASA applications of most importance are
1.Phased array communication systems for satellite to satellite links
2.Phased array radars for terrain mapping, surveillance, and satellite control
3.Infrared focal plane arrays for thermal mapping of foreign bodies
4.High performance data processors and cpu's for on board satellite computers
5.Optical routers, optical switching fabrics and optical fiber interfaces for satellite internal wiring
6.Optical transceivers, optical FPGA's (field programmable gate arrays), optical memories and optical bus networks
7.Optoelectronic IC's to reduce power and enable much higher clock speed for synchronous systems
8.High speed optical AD converters

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)
The non-NASA commercial applications are:
1.Next generation microprocessors. This is a huge global market ($400B) and is currently constrained by the saturation of the feature size. POET will replace most of these designs
2.Universal memory technology to combine static, dynamic and non-volatile memory functions
3.Optical transceiver market
4.Fiber to the home market
5.High speed data center. The POET processor will serve as the baseline technology for the next generation of high speed servers
6.Telecommunications will use POET ROADm's, POET optical switching fabrics and optical routers
7.High density memory - the POET thyristor will provide the universal memory technology as a basis for new system architectures
8.IR focal plane arrays for multiple markets including automotive.
9.The mobile electronic platform including smartphones , tablets and pads. The POET circuit will consolidate the processors into a single chip providing both RF and digital functions
10.All RF systems. For example the emerging wireless market at 60GHz is a perfect opportunity for POET as it is well within the bandwidth and allows POET to use radio over fiber techniques to perform the main distribution function.
11.The internet of things. POET is swell positioned to dominate this expansion of electronics into everyday control functions

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