Company Web Site URL: www.mortonphotonics.com
Point of Contact Name: Dr. Paul A. Morton
Phone Number: (443) 745 4779 Email: pmorton@mortonphotonics.com
DARPA Topic (1): SB062-017, 'Highly-Integrable Microresonators with Fast Tunable Group Delay for Broadband RF True Time Delay'
DARPA Project Contract Number (1): W31P4Q-09-C-0298
DARPA Topic (2): ST081-012, 'Miniature Silicon WDM Modulators for Analog Fiber-Optic Links'
DARPA Project Contract Number (2): W91CRB-10-C-0099
Phase II Period of Performance (1): SBIR Mar 2009 - 2011, Phase IIb to Feb 2013
(2): STTR June 2010 - May 2012, NCE to May 2013

Technical Challenge:
Morton Photonics (MP) is addressing the challenge of creating fully integrated photonic subsystems for RF photonic links and optical true time delay (TTD) in phased array systems, taking advantage of CMOS processing to create a silicon photonics system on a chip (SOC).

MPs technologies; Novel Ultra-Low-Noise Hybrid Laser / Linearized WDM Modulator / TTD Device, plus a commercial detector, provide the key optical components for a full TTD Unit.

MPs goal for project 1 is to provide a fast tunable TTD device with large tunable delay, high bandwidth and low distortion. MPs goal for project 2 is to provide a miniature, highly linear, WDM modulator, for use in high spurious free dynamic range (SFDR) links.

Prototype Description/Availability Date/TRL and MRL Status:
Novel time delay device and system level concepts have been demonstrated in project 1, and initial patents issued. On completion of the Phase IIb, project 1, aimed at developing commercially packaged products fabricated in a commercial foundry, the goal for these devices is TRL 6, MRL 8 (foundry).

Aspects of the device operation in project 2 have been demonstrated; full demonstration of a linear WDM modulator is expected by August 2012, with improved performance by the end of the program; the goal for this program at the end of Phase II is TRL 4, MRL 4 (Lab Fabrication).

Manufacturing Innovation (Technology and Processes)/Challenges being addressed:
MPs programs utilize silicon photonics nanophotonic devices, requiring advanced nanofabrication manufacturing technology. Project 1 focuses on transitioning the devices into a commercial CMOS foundry and commercial packaging. MP is looking for funding to transfer the linear silicon WDM modulators developed in project 2 to a commercial foundry. Additionally, MP is seeking funding to transfer their ultra-low-noise laser design to a silicon photonics platform, with the ultimate goal of integrating multiple photonic components onto a single silicon photonics SOC.

Potential Markets/Operational environments/Applications/End-users:
Applications include DoD and commercial markets for TTD units in phased array systems, e.g. phased array radar, directional communications, and electronic warfare. Highly linear RF photonic links can be utilized in a wide range of applications, within and between platforms, from fiber optic antenna remoting to free space communications. Operational environments cover the whole range from battlefield personal directional communications, ground vehicles, ships, and aircraft to satellites.

Systems Integration:
The TTD device developed in project 1, or a TTD Unit incorporating the device, needs to be integrated into a phased array system, e.g. X-Band phased array radar on any platform, or higher frequency phased array systems. The linear modulator developed in project 2, or full RF photonic link, can be utilized to replace bulky, expensive RF coaxial cabling on all platforms, or as an integral part of the TTD Unit.

Advantages/Value:

The optical approach in project 1 provides true time delay performance, which is necessary for broadband phased array systems. True time delay is currently not achievable with electronic devices, which provide only phase shifting. Optical integration into a silicon photonic chip provides over 10x improvements in SWaP, and similar cost reduction for volume manufacturing through the use of a CMOS foundry.

The linear WDM modulator developed in project 2 will make RF photonic links practical, providing high SFDR at low SWaP and low cost, compared to bulky, expensive, and limited performance electronically linearized Lithium Niobate optical modulators, which are currently used for RF photonic links. The linearized silicon photonics WDM modulator should provide 13dB improvement in SFDR for a system with 1GHz bandwidth over a link utilizing a standard Lithium Niobate modulator. The legacy technology is RF coaxial cable, which is bulky, heavy, and expensive, has significant loss at higher frequencies, and has a SWaP that is too large for many aircraft and satellite based systems. Replacing coaxial RF cables with silicon photonics integrated subsystems (transmitter, receiver) and optical fiber can also provide significant improvements at the system level, including immunity to EMI and EMP.

Technical and Manufacturing Risk and Mitigation:

The TTD devices developed in project 1 have been validated through prototype devices in prototype packages. The technical risk involves developing devices in a commercial foundry with improved loss performance, through the use of lower loss silicon and silicon nitride photonic waveguides. The manufacturing risks are associated with the commercial foundry being used to manufacture devices, and the commercial packaging partner.

The linear modulator devices developed in project 2 still require validation of device concepts through device fabrication and testing - the major risk here is the use of a University facility (Cornell) that does not have the same manufacturing environment as a well-controlled CMOS foundry. Additional funding would enable the transfer of the device designs to a commercial foundry (as in project 1), and then this technical and manufacturing risk should be significantly reduced.

Business model:

MP carries out device design, including modeling/simulations, and develops IP for these technologies. MPs facility includes a fully equipped optical lab for all testing of the fabricated and packaged devices. Manufacturing is carried out utilizing a foundry model, working directly with partners for the fabrication of devices and for the commercial packaging of those devices. Final device testing before product delivery is carried out at MP. MP has also developed a number of relationships with Prime contractors, who are interested in integrating MP technologies into their systems for delivery to the DoD.

Company Business Readiness:

MP develops advanced component and sub-system technologies for RF Photonics and future datacom / optical fiber communications systems, supporting both DoD and commercial markets. Silicon Photonics devices are being developed for optical time delay in phased array systems, linearized optical modulation for RF photonics systems, and to generate complex modulation formats in high speed digital systems. High linearity analog systems are being developed through a combination of silicon photonics devices and MPs ultra-low-noise lasers. The company is well positioned through its business model, its strong partners, and through the experience of its executives to meet all business and operational requirements to transition the technologies to products for delivery to DoD and commercial markets.

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