Topic: N15A-T023

Radiation Detection Technologies, Inc.

Advanced Silicon Diode Switch for HPRF Systems

The advanced technology RDT is developing is a Si-based photo-conductive solid-state switch (Si-PCSS) 10kV-module for coupling to different microwave radiation technologies. RDT develops and commercializes state-of-the-art semiconductor devices that have been laboratory proven by RDT and collaborating Universities. Applications that benefit from Si-PCSS technology include: microwave-emission devices driven by non-linear transmission lines, and firing sets and superposed antenna, whose phase alignment require picosecond coordination. The uniqueness of RDT's Si-PCSS technology is its fast rise-time, low jitter, low laser-energy trigger, high average power, solid-state robustness, operation at hundreds of kHz, and maturity (VLSI silicon: availability, manufacturability, reproducibility). The combination of the silicon switch and the laser allows for meeting all the pulse and timing requirements set forth by the Navy without the need for vacuum electronics.

Technology Category Alignment:

Radio Frequency Weapons (RFW)
RF Components for sensing, transmission and communication
Sensors, Electronics and Photonics
Power Generation/Energy Conversion
Power and Energy

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SYSCOM: ONR
Contract: N68335-17-C-0041

Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N68335-17-C-0041

Department of the Navy SBIR/STTR Transition Program

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Advanced Silicon Diode Switch for HPRF Systems
Radiation Detection Technologies, Inc.

WHO

SYSCOM: ONR

Sponsoring Program: ONR 352

Transition Target: High Power Radio Frequency Microwave Emission Devices

TPOC:
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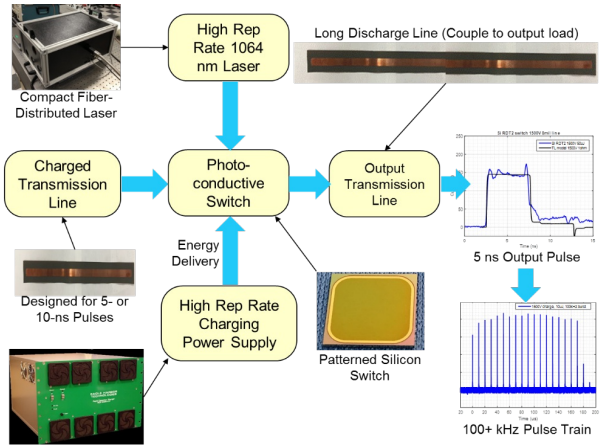
Other transition opportunities: Pulsed Power users in the Department of Navy (DON), Department of Defense (DoD), Department of Energy (DOE), and commercial sectors



Notes: Conceptual diagram of the top-level design of the silicon photoconducting solid-state switches (Si-PCSS) based high-voltage current-switch with key building blocks for High Rep Rate Pulse Power Systems and High Power Radio Frequency (HPRF) Applications. The uniqueness this technology brings, is its fast rise time, low jitter, low laser energy trigger requirement, high average power, solid-state robustness, and maturity (silicon availability, manufacturability, reproducibility).

WHAT

Operational Need and Improvement: ONR identified a need for new solid-state switches in standard form-factor mountings; envisions their use in HPRF applications. Program goal is to jumpstart a commercial switch package design, focusing on fast rise-time, cooling considerations for continuous operation, and improving/optimizing the switches for operational use. Si-PCSS are presently the only semiconductor-based switches used in commercially available HPRF instrumentation. The overarching problem is one of tradeoffs, as one material system has not been able to meet all needs.

Specifications Required: Design Parameters for a new solid-state switch (diode):
• 1.5 kV switch voltage (Target 10 kV switch voltage); • 500 ns or less recovery time; • 150 A On Current; • 10 ns pulse lengths; • 1 picoseconds jitter; • 100 ns charge times; • 1 ns rise times; • 500 kHz pulse repetition frequency; • 1 hr run time; • Packaged in a standard industrial form factor.

Technology Developed: The advanced technology RDT is developing with its partners University of Missouri Kansas City (UMKC) and BAE Systems, is a Si-PCSS 10kV-module for coupling to different microwave radiation technologies. RDT develops and commercializes state-of-the-art semiconductor devices that have been laboratory proven by RDT and collaborating Universities. The uniqueness of the Team's Si-PCSS technology is its fast rise-time, low jitter, low laser-energy trigger, high average power, solid-state robustness, operation at hundreds of kHz, and maturity (VLSI silicon: availability, manufacturability, reproducibility). The combination of the Si-PCSS and the laser allows for meeting all the pulse and timing requirements set forth by the Navy without the need for vacuum electronics.

Warfighter Value: RDT's low SWaP Advanced Silicon Diode Switch technology with its fast rise time, low jitter, low laser energy trigger requirement, high average power, and solid-state robustness, is capable of switching from very high voltage to very low voltage states in the hundreds of picosecond regime. High repetition rates are required for use in High Repetition Rate Pulse Power Systems and HPRF/ Directed Energy (DE) applications. This technology combines Si-PCSS and LASER to eliminate the need for vacuum electronics, which significantly increases reliability and makes it ideally suited for use in DE applications aboard forward-deployed vessels.

WHEN

Contract Number: N68335-17-C-0041 **Ending on:** November 16, 2020

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Demonstrate to PCSS requirements	High	Hetero-structure Si-based switch based on the Phase I work that meets the Phase II metrics.	5	August 2018
Demonstrate to pulsed-power requirements	Med	A compact assembly comprising the transmission line, Si-PCSS switch and cooling system, including provision for system level integration with laser and high voltage charger.	6	August 2018
Work with partners to demonstrate HPRF power	Med	Add a transformer and NLTL connector to the Phase II Base transmission line, switch, and cooling assembly.	6	May 2019
Final system delivery	High	A fully integrated system that includes a COTS or GOTS NLTL and COTS, GOTS, or custom radiating structure.	7/8	November 2020

HOW

Projected Business Model: RDT will focus on manufacturing and assembling the Si-PCSS HPRF system for integration into higher-level instrument applications. Silicon-based photoconductive switches fill an existing need and will continue to do so for the next five to ten years; afterwhich, the competitive advantages of alternative technologies may resolve issues with manufacturing. The focus at that point will be on being cost competitive.

Company Objectives: Commercialization of the photoconductive solid-state silicon switches developed for this project will be driven by the needs of the Navy, wider-DoD community, DOE community, and commercial pulsed power users. In the case of the overall high power microwave system, for which the switches are one sub-component (power supply, triggered switches, non-linear transmission line, and antenna), BAE Systems (a Prime) will be the lead integrator, overseeing both the engineering aspects of putting all elements into a single user controlled system, as well as transitioning this instrument to the Navy and greater DoD base given their longstanding and trusted work as a major defense contractor/supplier.

Potential Commercial Applications: Applications/markets that benefit from these attributes include microwave emission devices driven by non-linear transmission lines, firing sets and superposed antenna (i.e., addition and beam steering) whose phase alignment require ones-of-picosecond coordination, and similar applications. The first product the switch modules will go into are high voltage pulsed power supplies; this product will include the laser trigger, fibers, and switch modules as a package; the technological advantage is a one order-of-magnitude improvement in jitter and switch rise time. The commercial customers includes those industries which serve to integrate these unique power supplies for treatment of water, gas, food, wood, coatings, and metalworking, as well as non-lethal defense technologies, and a wide range of medical instrumentation.

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