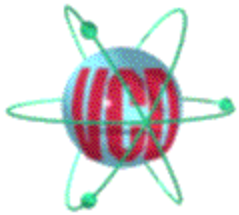
Static Event Health Monitoring
A Capability Improvement Program
Progress Report 27 March, 2007

Tom Odom
VCD Technologies
San Dimas, California

Niels Jacksen

Technical Coordinator

Dr. Jim Karins
Pukoa, LLC

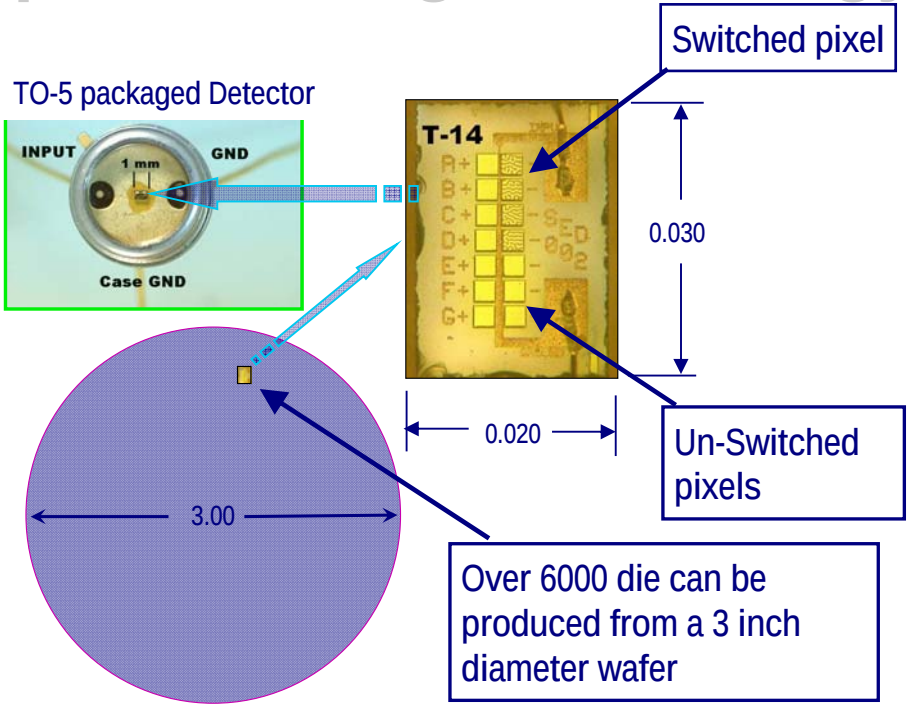


Presentation topics

- Review of Magneto-Optic ESD Sensing Technology
- CTMA Initiative Overview
  - Key Design / Performance Parameters
  - Deliverables
  - Progress for the first six months ending March06
- Progress for the last 12 months
  - Detector Fabrication
  - Readout/Reset Technology
  - Static Sensitive Test Circuits
  - Detection/Protection Prototype Circuit
- Plans for the conclusion of the Project
  - Deliverables
  - Beta Site Testing
- Conclusion

Overview of Magneto-Optic Sensing Technology

- Bubble Memories
  - Developed in the 1970's as an alternative to magnetic tape data storage
- Light Modulation Devices
  - Developed for Military applications in the 1980's.
  - Used Single Crystal Magneto-Optic wafers to modulate light in nano-second time frames for Missile tracking applications
- Magneto-Optic Static Event Detectors (MOSED)
  - Prototypes developed in the late 1990's
  - Created to aid in the detection of ESD events.
  - Magnetic fields created by the ESD transient changes the properties of the Magneto-Optic thin film deposited on a single crystal substrate
  - Devices can be remotely reset
  - Effect is observed using a polarizing microscope



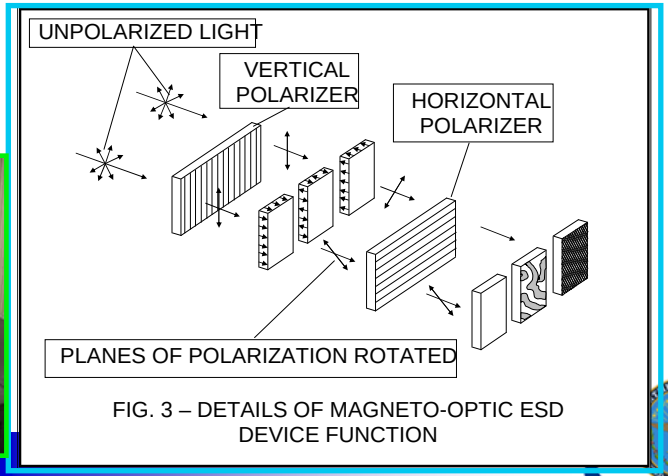


FIG. 3 – DETAILS OF MAGNETO-OPTIC ESD DEVICE FUNCTION

CTMA Initiative Overview
Design Performance Parameters, Deliverables and Status

Phase	Phase Objectives	Details	Deliverable	Status
1	Establish MOSED and Reader Performance Objectives and define design concepts	MOSED Device shall have an initial trip level of 500 V* ± 100 V and fuse trip level of not less than 2500V* MOSED packaging: < 25mm square X 5 mm thick MOSED to contain registration elements to evaluate Reader proof-of-concept devices Reader: Use COTS electronics and electro-optic devices. Minimize use of precision alignment to detect changes in MO material.	Design and fabricate prototype MOSED Design, procure and evaluate COTS hardware simulating the Readout device using proof of concept MOSED Deliver three (3) packaged prototype MOSED's to AFRL-TAD for characterization testing	**Completed June06**
2	Design& Deliver Static Sensitive Test Circuit (SSTC)	SS Device threshold sensitivity >500V HBM (90% confidence SS Device is damaged with Human Body Model (HBM) events >1000V) MOSED / SSTC package < 25mm square X 5 mm thick	Fabricate, package and deliver ten (10) SSTC's Fabricate and deliver prototype reader	**Completed November 06**
3	Design and Deliver Detection/Protection Devices	DP Trip at computer surge levels >130 V RMS, sustain >15 A peak transient. Sustain >2500 V surge without performance degradation EOS/DP Readout system: Demonstrate Reader prototype. Minimize Component cost. Lower alignment and distance from EOS/DP requirements Perform Beta Site Testing	-Ten (10) ElectroStatic Protection und Detection ESPUD devices using MOSED's integrated with Voltage Variablre Devices (VVD) structures -3 Readout Devices for MOSED -Final project report. -Application workshop reports. -Technical description of SED Health Monitoring implementation.	Prototype under evaluation Beta Site testing planned for summer07

Risk Reduction and Mitigation

Risk reduced:

- Multiple Deliveries
  - MOSED Device in discrete package
  - Static Sensitive Test devices integrated with the new SED to characterize performance
  - jnh for wide range of ESD sensitive devices
- Diverse Applications
  - Surge Suppression device will be co-developed
    - Use state-of-the-art surge suppression technology
    - Couple with MOSED to identify existence of surge
- Government Review and Concurrence throughout development cycle
  - Multiple Workshops and design reviews to obtain government input were conducted
  - Reduces risk of redesign to meet user needs

Role of Government Labs

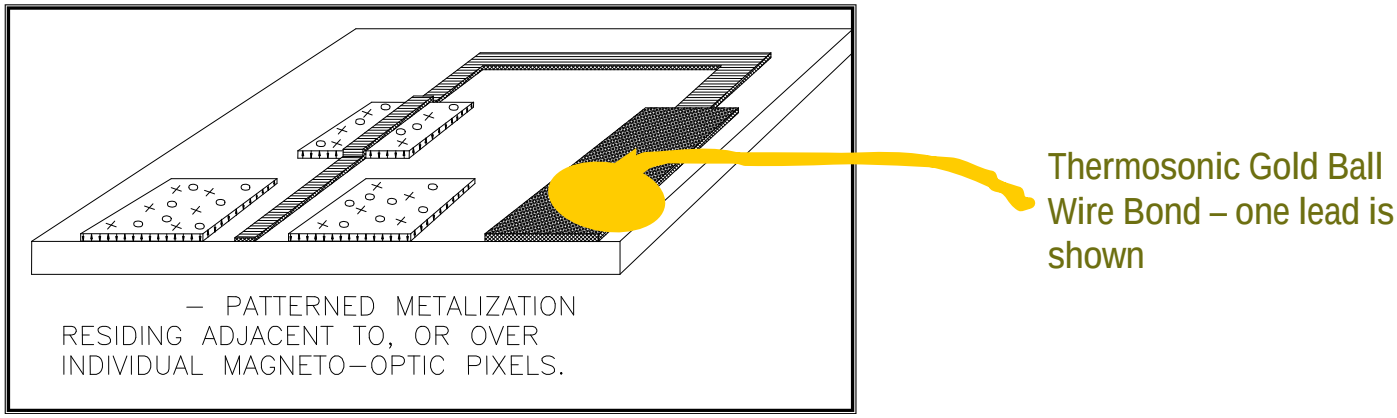
- WPAFB / AFRL
  - Use of test facilities calibrated instrumentation and trained test personnel to characterize prototype devices and deliverables
  - Voice of the customer for feed back into utility of devices in real world applications
  - Guidance to prepare a paper for the annual EOS-ESD society convention in September
- TAD / WRAFB
  - Access to electronics labs test facilities applicable to ESD susceptibility and damage assessment (forensics) characterization
  - Technical assistance to assess utility of prototype SSTC and EOS/DP

Progress

- Detector Fabrication
  - MO Wafer Process Development
  - Detector Assembly Technology Advances
  - Detector Characterization
  - Proposed MOSED Packaging for Reader / Reset Proof of concept devices
- Readout / Reset Proof of Concept Progress
  - Key Parameters
  - Trade Study Risk Assessment
  - Feasibility Testing
  - Block Diagram for Phase 2 Prototypes
  - Features, Benefits & Single Unit Pricing

Detector Fabrication Prior Art

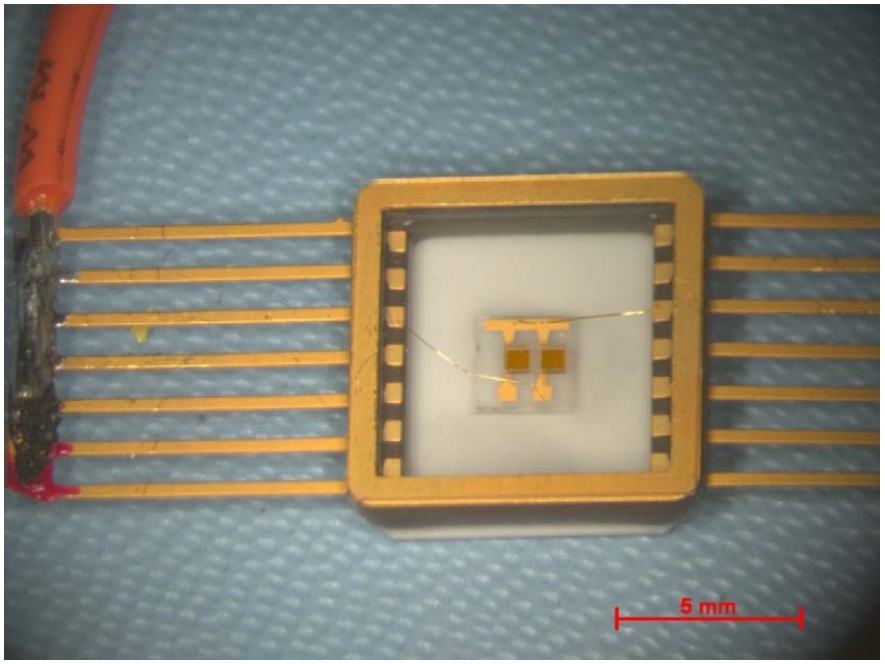
- **Detector Prior Art**
  - M-O Thin film is grown over non magnetic substrate wafer
  - Wafer is photodelineated and etched to form pixels / domains in the
  - Wafer is selectively metallized to form a sensing electrode. The metallization is designed to accept Gold wire thermosonic bonds



- **Advantages**
  - Small Size: The detector die can be as small as 500 microns x 750 microns
  - Simplicity – All the complexity is handled on a wafer scale.
    - Lowest cost for High Volume applications
- **Disadvantages**
  - Not efficient for development projects where wafer availability is severely limited…Such as the CTMA projects
  - Difficult to evaluate multiple electrode configurations needed improve detector R&R and to produce MOSED's with alternate sensitivities

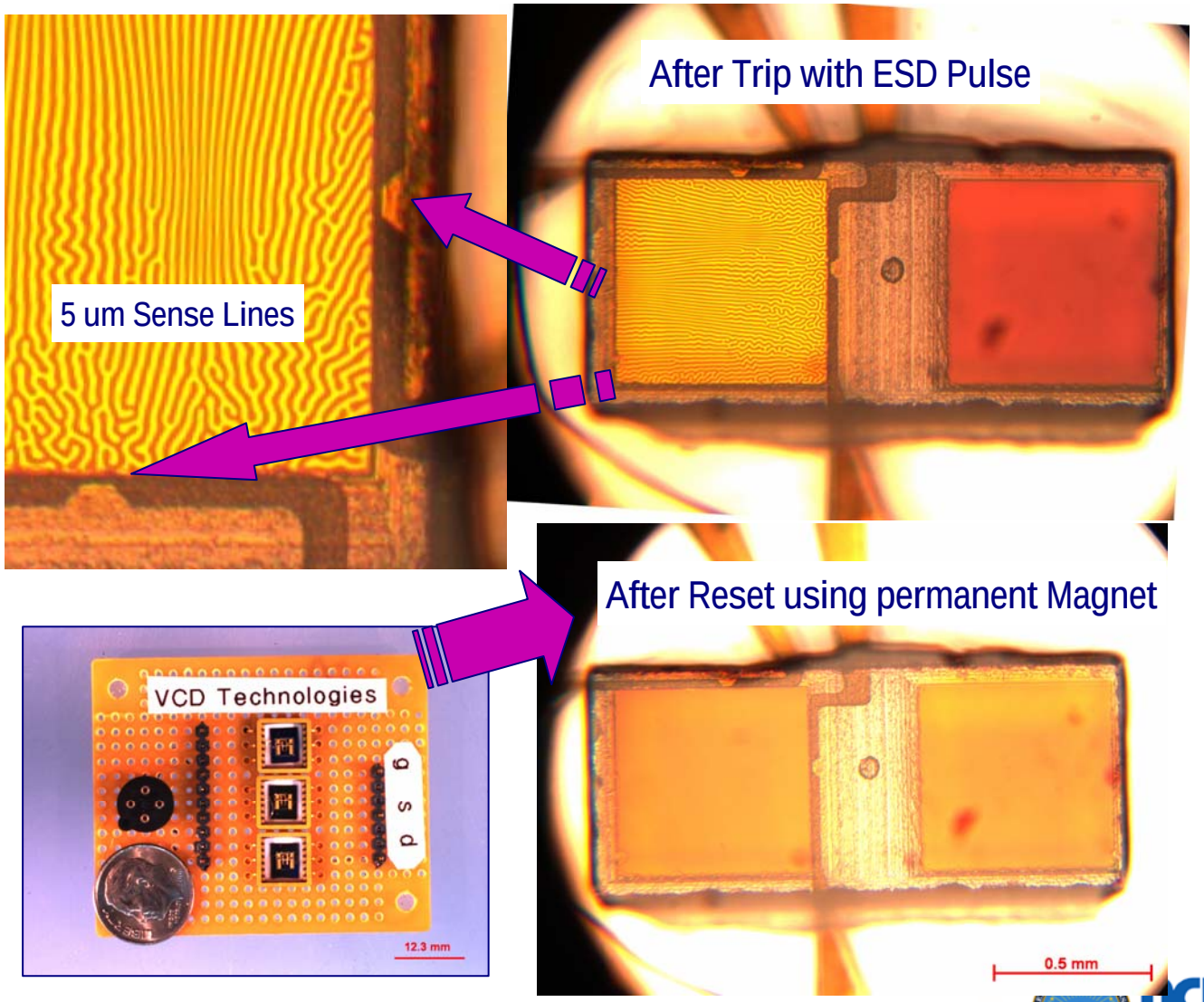
Magneto Optic Device Development

- The Detector magnetic domain pixels are created using commercial micro-electronic processing equipment
  - Special processing is used to passivate the detector's surface to ensure repeatable switching characteristics
- A substrate is photofabricated containing a thin sensing
- electrodes (extended lead frame) are fabricated on separate ssubstrate
- Detector structure is flip chip bonded to extended lead frame
- Advantage
  - Inexpensive method to demonstrate pixel design R&R and to fabricate multiple detectors with different sensitivities
  - Rugged photofabricated sense lines increased fuse level from ~2000V to over 10,000 V



Demonstration Testing @ WPAFB on 6 Nov06

- Prototype detectors have been build that meet current HBM specifications
- Device testing for stability and performance reproducibility for Phase 2 completed
- Prototypes readied for demonstration of Phase 3 Detection/Protection Devices



Reader / MOSED Capability Goals

Concept of Operation

- To read the MOSED, a Reader is placed above and in proximity to the MOSED to determine its state of polarization
- To reset the device, a permanent or electro-magnet device is integrated with the readout device

Criteria	Metric
Imaging capability	Camera does not require Auto Focus
Position of camera/reader with respect to SED	>1.0" , <18.0", Optimum distance=12"
Platform adjustment	Device shall be on an adjustable platform with 2.0 " minimum variability
Camera Depth of field	>1.0" depth of focus at the specified height setting
Positioning accuracy of SED with respect to reader	Reader shall be able to function (discriminate between MO states) when SED is positioned within 0.25" of the optical axis of the reader
Declare time	<5 sec duration between reader initiation and declaration
Parallelism	Reader shall be able to accurately declare an event if SED is up to 5 degrees out of parallel with respect to the reader

SSTC Design and Demonstration

- PCB Configuration
  - 1 3N169 FET Transistor
  - 3 MOSED's connected to Source, Gate and Drain of FET
  - Terminals to accept test wires

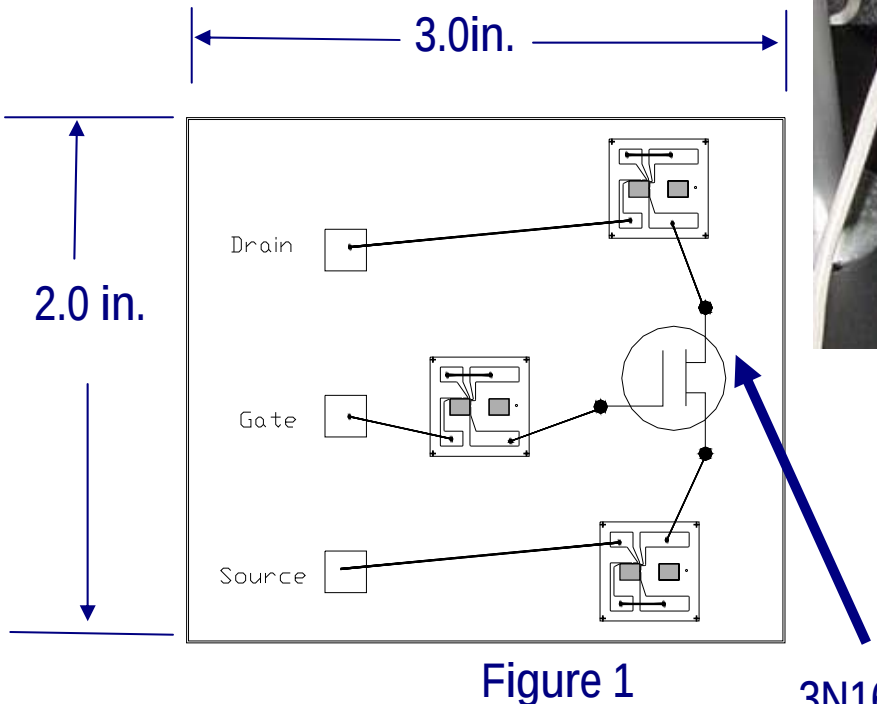
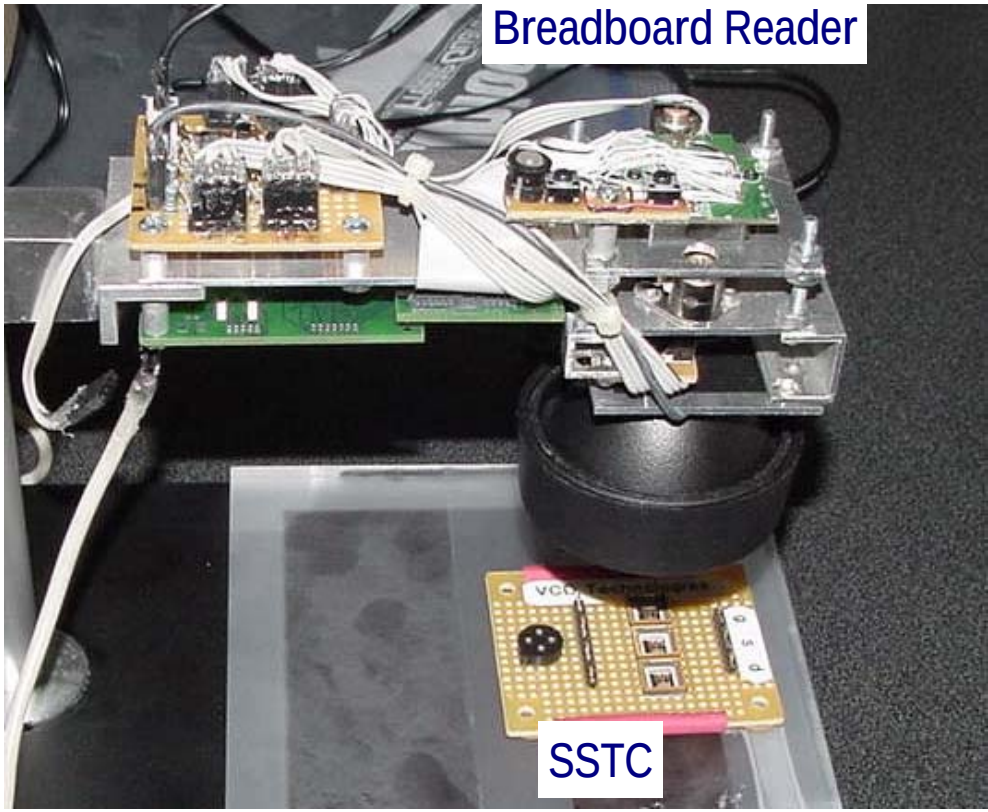


Figure 1

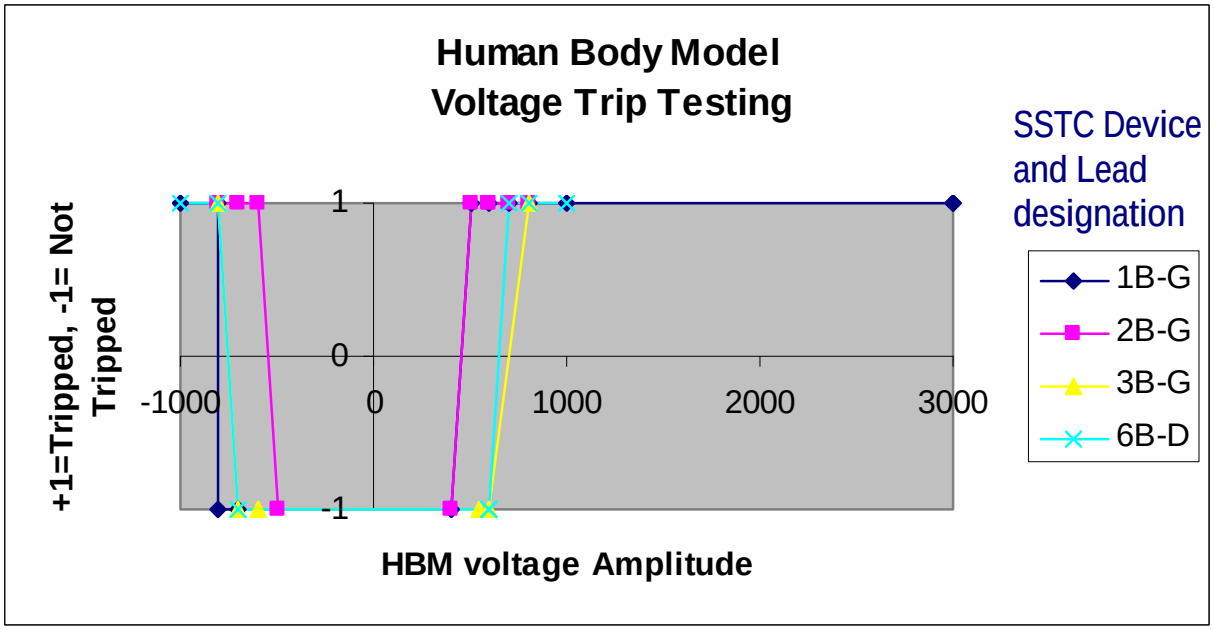
3N169 FET



Technology Demonstration @ WPAFB on 6 November06

SSTC Test characterization

- Demonstrated Repeatability using variable threshold testing
- 100% compliant to the 1000V threshold requirement



Reader Design Evolution

- Present state devices are reaching commercialization
- Processor size reduction requires stand alone FGPA processor
- Optics integration of MOSED and Reader is on-going – expected completion 2Q07

Insert Photo of new slick Reader

Phase 3 – Static Health Monitoring Initiative Devices

- Goal:Integrate MOSED and Reader with an appropriate EOS/ESD Protection Device
- Tasks
  1. Perform trade Study on available protection technologies
  2. Downselect and develop a prototype device for demonstration
  3. Perform Beta Site testing using prototype devices

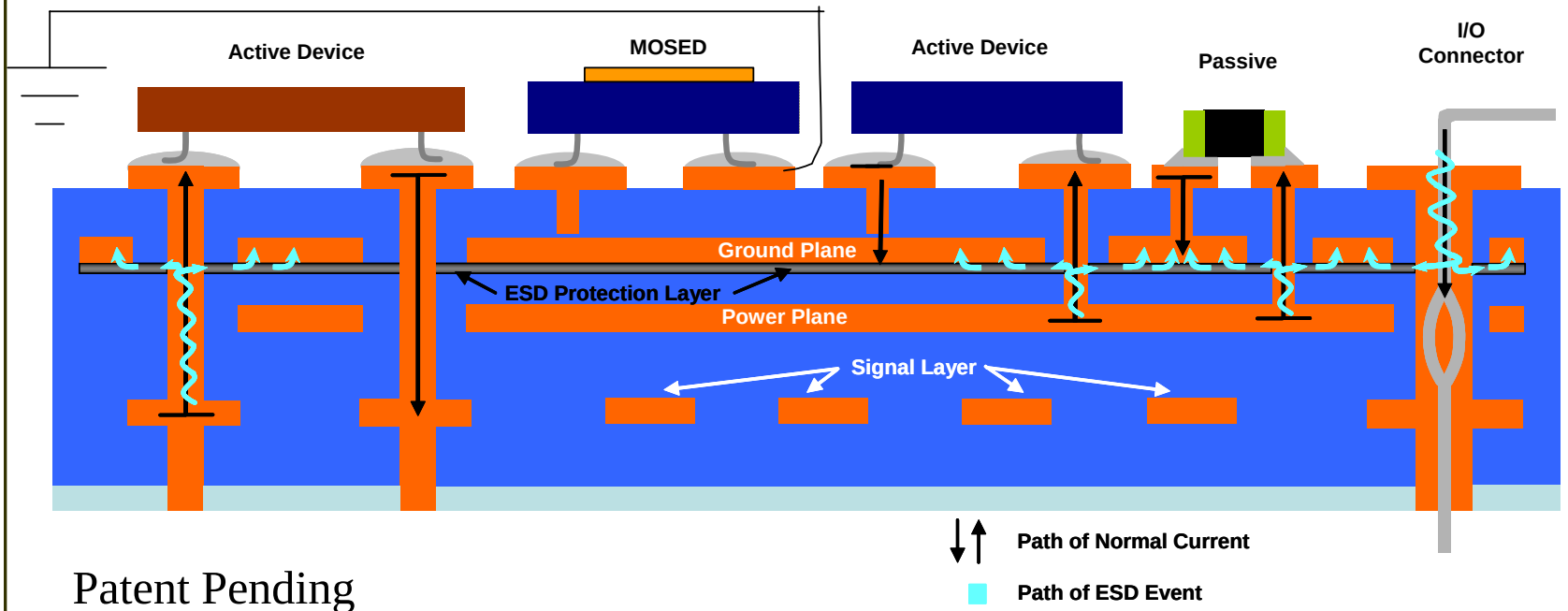
Trade Table for Identified Static Protection Technologies

Technology	Advantages	Disadvantages
Zener Diodes	Mature Technology	Requires individual interconnects for each channel
	Inexpensive cost ~$0.1 /device	
	Can be fabricated into array for multiple channel applications or integrated into monolithic Silicon device	
	Fast switching (~ 1 nsec)	
	Easy to integrate with MOSED. MO will detect current passed by a transient that exceeds Zener breakdown voltage)	
Thyristor	Mature Technology	Relatively expensive (~ $1)
	Allows for Gated operation. Will switch positive or negative polarity transient pulses	Requires individual interconnects for each channel
	Easy to integrate with MOSED. MO will detect current passed through the Thyrister once it has been switched into its transconductance state	Switching speed issues (10's to 100's of nsec)
Polymer Switching Devices	Mature Technology	Switching time (microseconds)
	Inexpensive cost ~ $0.1 /device	Requires settling time to revert to conducting state
		Requires individual interconnects for each channel
		Issues with MOSED integration. Will the transient be detected if it is open circuited
Voltage Variable Dielectric	Allows for global protection on single layer of PCB.	New unproven technology – Still in development phase
	Single MOSED design concept allows for detection of a transient anywhere on the circuit.	Characteristics TBD (to be disclosed upon execution of non-disclosure agreements)
	Low Cost – Developed for Cell Phone and related commercial applications	

Embedded ESD Protection Integrated with MOSED

Demonstration Device

- **Uses existing Sanmina demo PCB's**
  - **Planar VSD material layer is deposited under the ground plane**
  - **All PTH and blind vias that contact the VSD material layer are protected, regardless of function**
  - **Normal current path is not effected as VSD material acts as insulator**
- **Replace Active device termination with MOSED as shown**
- **Shunt wire from one MOSED terminal to ground**
- **When ESD event occurs, VSD material becomes conductive and shunts the ESD event to ground plane, through the MOSED, recording the event while allowing for full protection**



Patent Pending

Plans for the conclusion of the Project

- Deliverables
  - Quantities and configuration of deliverables have been modified to allow industry to focus on integration of the new Detection/Protection technology
    - 10 Detection/Protection devices to be delivered
    - Requires delivery of new Voltage Variable PCB's from Shocking/Sanmina
- Beta Site Testing
  - TAH to provide facility
  - SSTC's and new Detection/Protection devices to be evaluated in a Depot Health Simulated Program
  - Goal: demonstrate how new detection and protection technologies can save program $'s
    - Minimize losses due to handling in the field
    - Identify ovvrstress as well as ESD transient

Conclusions

- The Existing MOSED technology is on schedule to provide benefit to the Military in general and Depots specifically as a Static Health Monitor.
- A prototype reader has been designed, fabricated and demonstrated
- New designs for the MOSED have been executed to demonstrating meeting the long term objectives of the CTMA cost share program
- New protection technologies are being evaluated as an integrated detection/protection technology that may soon be available on legacy, replacement and new generation electronic products.
- A Beta site integration program will be planned and executed to complete the CTMA program in 2Q07