Electronic Polymers Inc.

The next wave in ESD protection

ELECTRONIC POLYMERS INC.

EPI-FLO™

IMAPS Advanced Technology Workshop

Rancho Cordova, CA May 4, 2005

ESD Protection of an RF Integrated Circuit By Embedding Protection in the IC Printed Circuit Board

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Outline

- The ESD Dilemma: Performance versus ESD Reliability
- EPI Tests Bridges the New-Old ESD Standards Gap
- EPI's EPI-FLO™ Products fit GHz ESD Needs
- EPI test methods for EPI Vtrigger spec for GaAs Module
- RF test data for EPI-FLO™ on GaAs module
- Embedded EPI in IC Package aligns with NEMI Initiative to Embed 40% of passive devices by 2008
- EPI-FLO™'s potential to remove Roadblocks to Moore's Law
- Summary

ESDA Roadmap Shows IC Sensitivity

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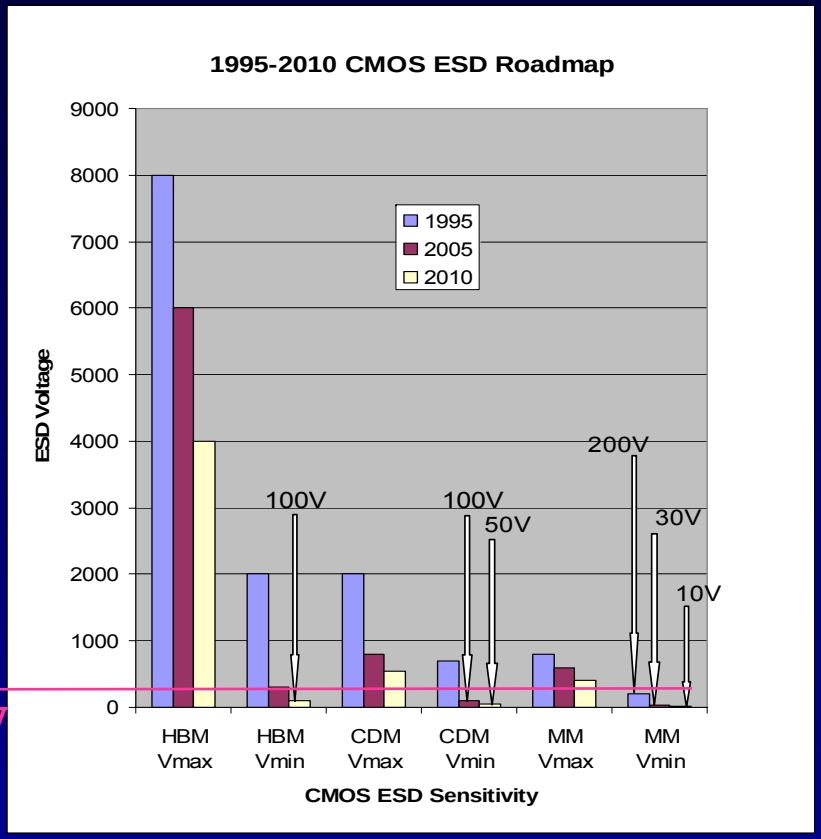
National ESD Association ESD Technology Road Map shows engineers are sacrificing ESD reliability for performance in Human Body Model, Machine Model and Charged Device Model.

Min/Max boundaries represent ESD sensitivities determined by IBM, Intel and TI engineers. (2005 ESDA Association)



CDM class II >200V<500V

New Standards are emerging which are even more severe: System Level ESD, Cable ESD for Handhelds, for Servers, and Automotive ESD

Chip ESD Sensitivity is Getting Worse

EPI-FLO™

- ESD damage is getting worse due to:

Smaller IC geometries

Higher frequencies

Escalating #'s of signal lines

Combined with

Reduced board space

Decreasing capacitance budgets for ESD protection

Reduced budgets for ESD protection on chip & on PCB

- EPI-FLO™ Polymer Voltage Suppressors (PVS) low capacitance ESD protection increases GHz Electronics availability by increasing reliability.

Portable Electronics Need ESD Protection

LO™

ESD Journal Home Page

ESD Journal™

Good Afternoon! It is currently 4:42 PM on Thursday, June 24, 2004.

Palm Inc. Sued for ESD

Vanessa Hua of the San Francisco Chronicle reported that Palm, Inc. has been sued for ESD problems. The lawsuit, filed in August in San Francisco County Superior Court, claimed the function that allows people to synchronize the data of the mobile device to their PCs "damages or destroys the motherboards on certain PC brands."The suit did not specify which Palm models were allegedly defective or what kinds of PCs were affected. The Pinnacle Law Group of San Francisco, which filed the suit on behalf of California residents Melissa Connelly and Laurence Stanton, seeks class-action status.

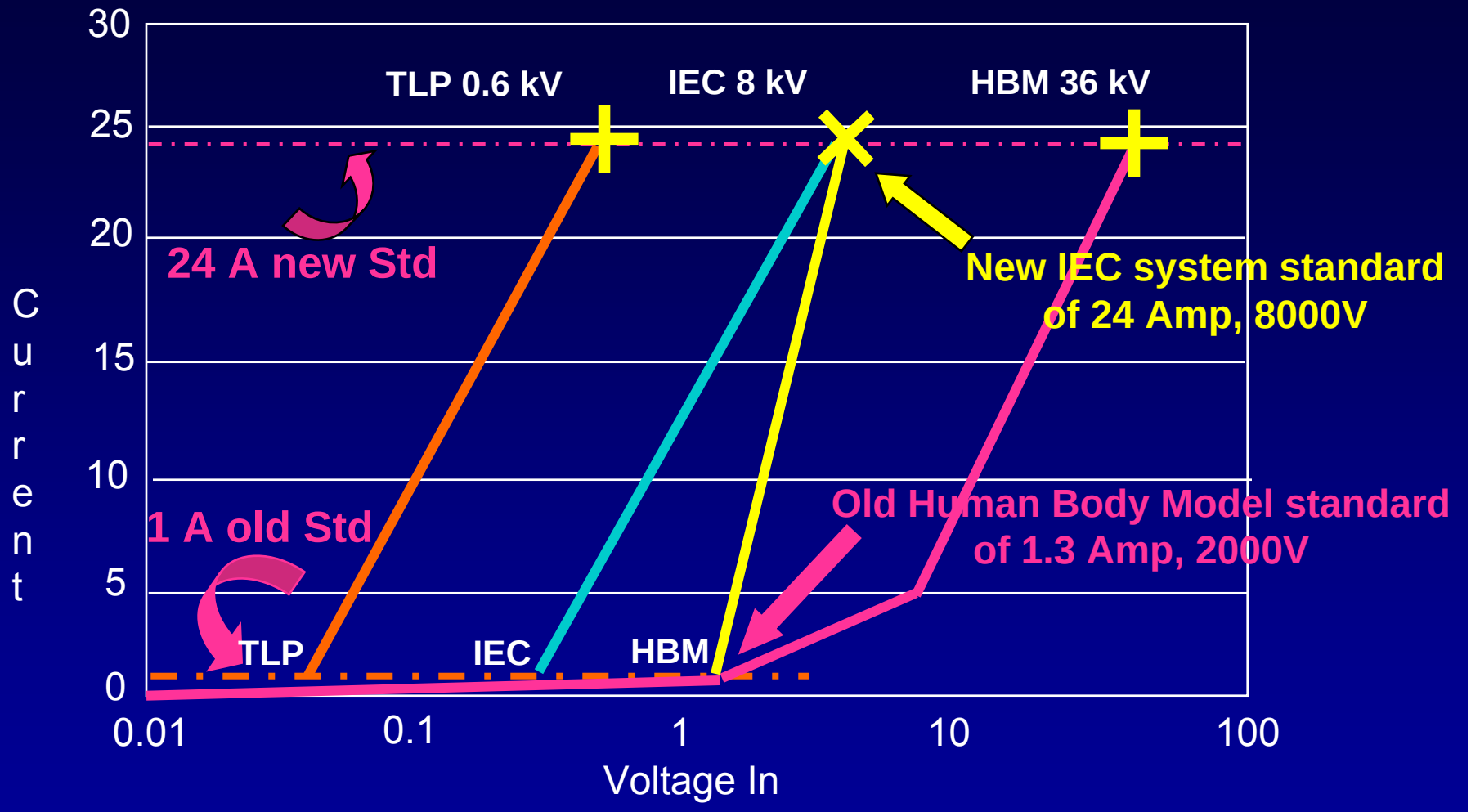
ESD Journal's attempts to obtain comments from the Santa Clara based Palm, Inc., which has sold more than 13.7 million of its devices, have been unsuccessful.

Steve Fowler of Fowler Associates, Inc.,an ESD Consulting firm, stated that his company has received reports of ESD problems with handheld devices such as audio players and PDA'a. The problem of static electricity with handheld devices is growing. As devices become faster, grow smaller and more sophisticated so does their sensitivity and therefore their vulnerability. Some of the problems have been discomfort to the user such as discharges to the ear of an MP3 player user. Others have been damage to the PDA or the computer to which it may be connected. Mr. Fowler stated that any heldheld device by being carried builds a static charge as the user moves and walks. Then when it is plugged in its cradle, a static discharge or ESD event may take place. Some handheld audio devices have been reported to have severe ESD events to the user's ear from the earphones. This is similar to the case reorted by Call Center operators. **Shock in the Call Center**

Use & cable ESD from docking damages portables. EPI's 2004 National ESDA paper shows System ESD is 24X the current of HBM ESD. The paper demonstrated using EPI-FLO™ ESD protection to a make GaAs module System Level ESD compliant .

EPI's TLP Test Protocol Helps Engineers Bridge the Gap between System & IC ESD Standards

EPI-FLO ™



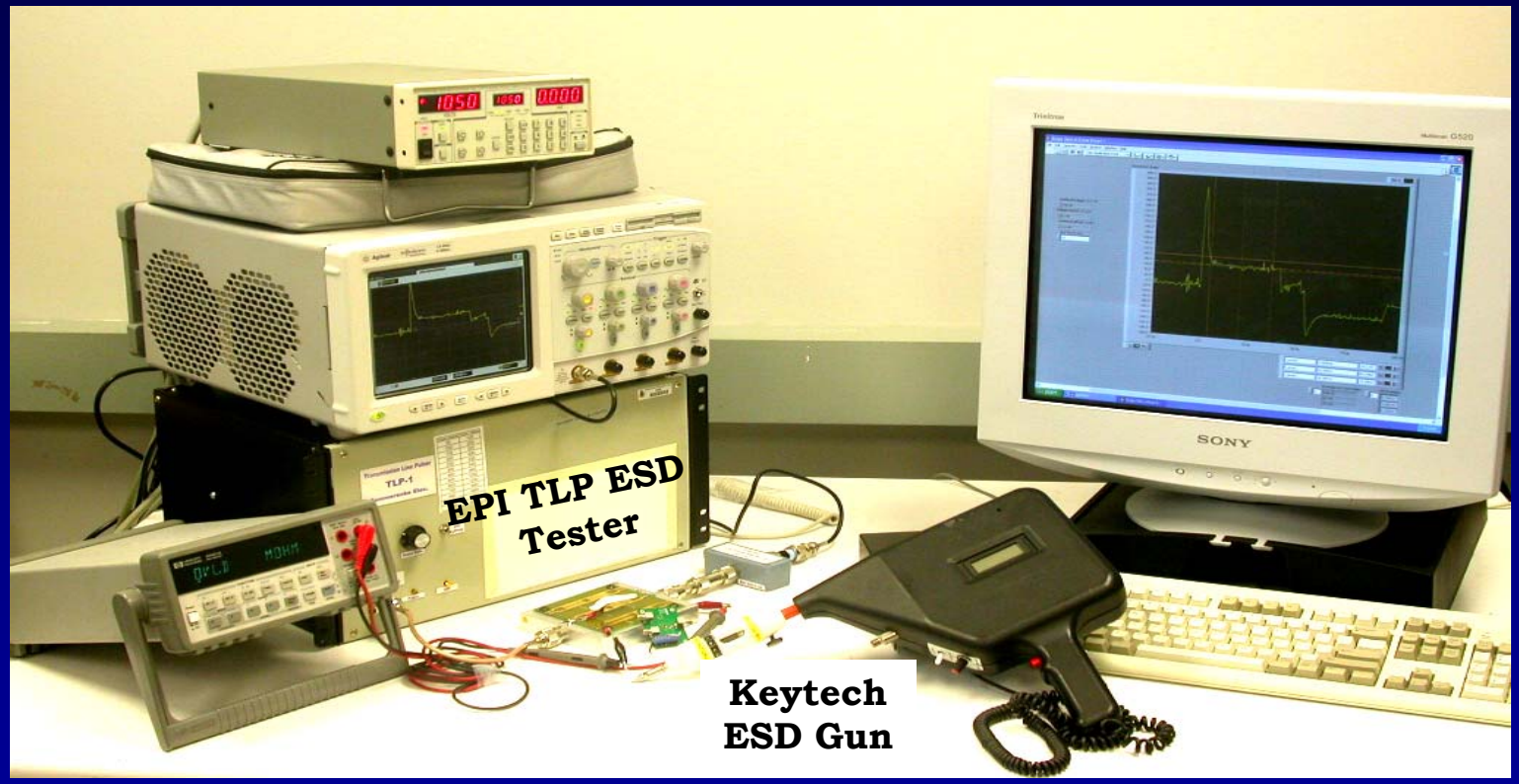
Electronic Polymers Products

- EPI Transmission Line Testers (TLP's), and EPI-FLO™ products provide ESD solutions for sensitive chips
- EPI's unique component manufacturing process is a paradigm shift in passive component manufacturing. Printed circuit board processes are used to image EPI-Core laminates for multiple Surface Mounts, Connector Arrays and Embedded designs
- EPI-Cores are nanosecond polymer voltage switches laminated between copper electrodes
- The fF capacitance of EPI-FLO allows protection of RF components without interfering with signal

TLP/ESD System Testing

EPI-FLO™

TLP is used to define EPI-FLOTM Vtrigger needed to protect sensitive IC to ESD specification



TLP testing is correlated to ESD Standards.

EPI's Newest TLP

EPI-FLO™

- We plan to set the TLP Standard for:
  - HBM, MM, CDM, IEC 6-1004-2 (System Level)

EPI's Newest TLP

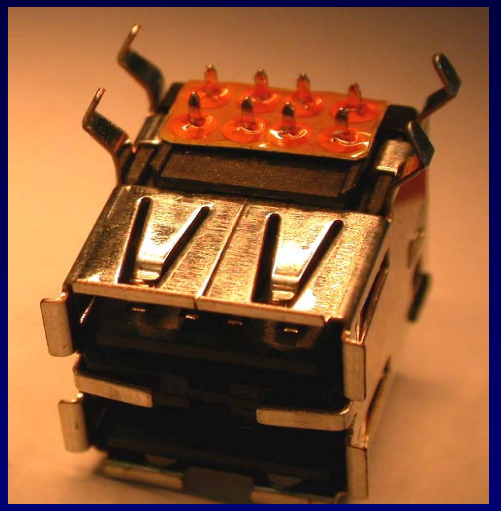
EPI-FLO™

- Keep the Wolves from Your door

EPI-FLO™ Fits RF Space & ESD Needs

- Capacitance < 150 fF
- Multiple line ESD protection
- Bipolar
- Low profile, ≤10 mils (0.25 mm)
- Pico-second ESD response
- Zero board space on a connector
- Substrateless Surface Mount

Surface Mounts



USB, RJ-45 (Ethernet), EPI-FLO™ Connector Arrays

Surface Mount devices & multiple line protection Connector Arrays led to Embedded ESD EPI-Cores

EPICore Embedded In 4 Layer PCB

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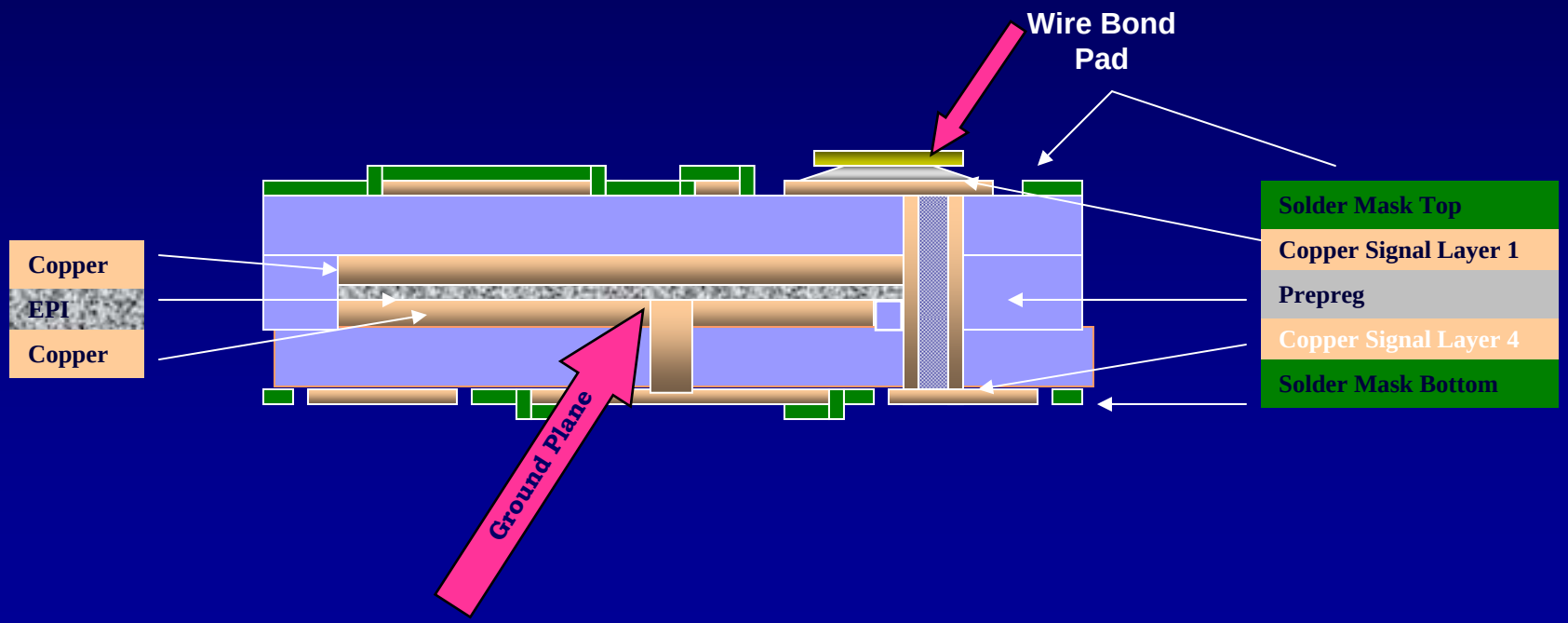
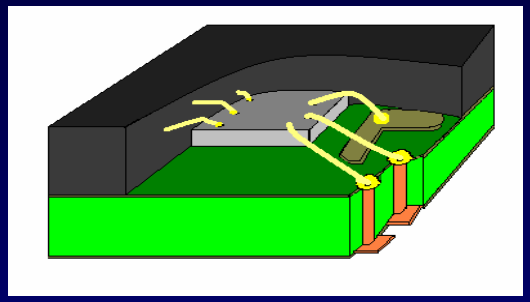
Fabrication Design for an EPICore inserted in a FOUR Layer RF Module Providing Multiple Line ESD Protection for a GaAs Chip Package



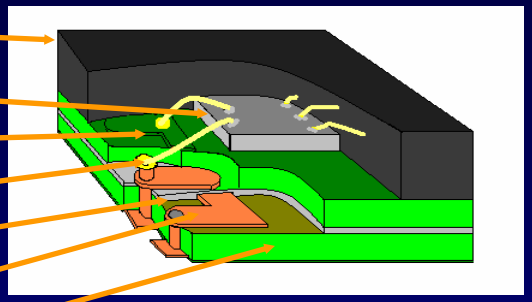
EPI Core Embedded in GaAs package

EPI-FLO™

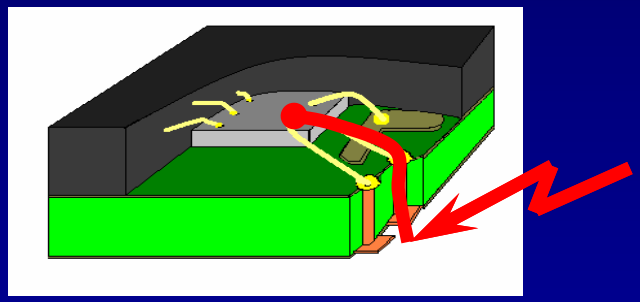


20 mil pkg without EPI-Core

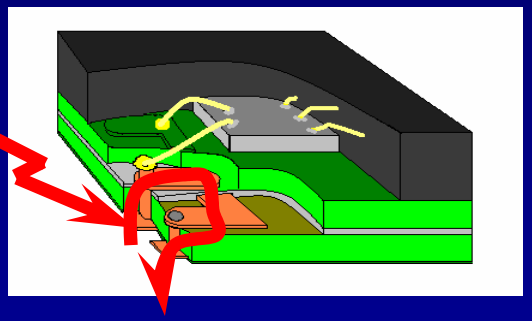
Encapsulation
Die
Solder mask
Copper
EPI
Electrode
Laminate



23 mil pkg with EPI-Core



No protection Damages IC



ESD protection with EPI Core

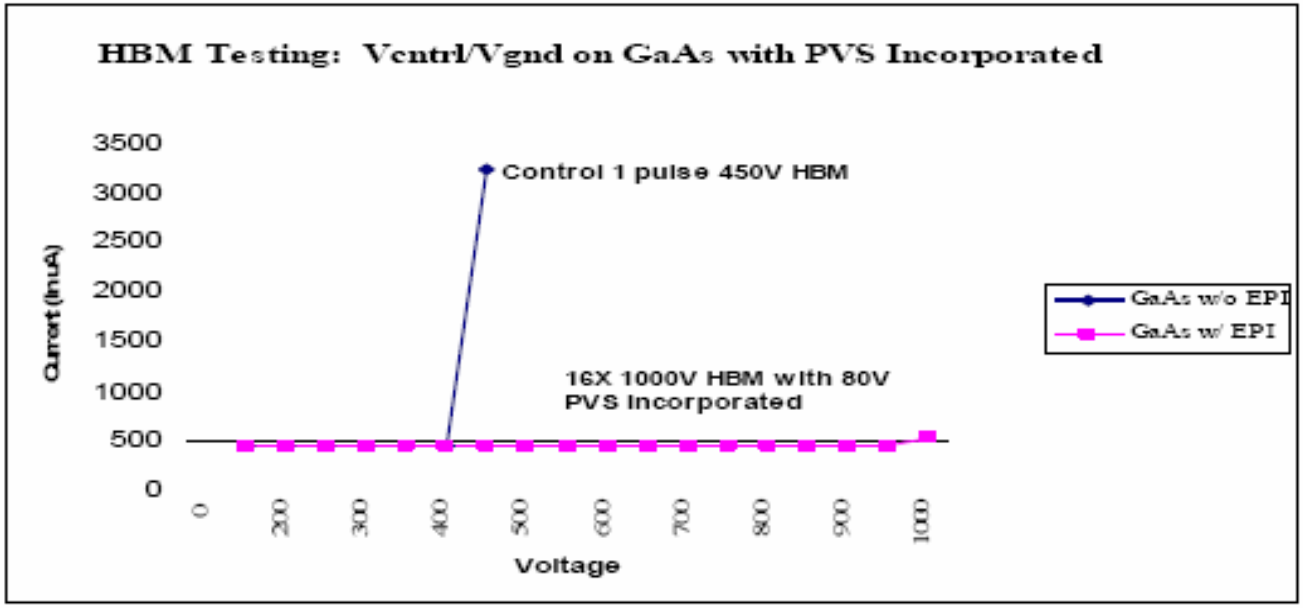
Testing for ESD Protection of RF Module

EPI-FLO™

1. Test equipment includes a 200ps rise time TLP, a HBM and MM IC tester, and a MM ESD gun
2. The power module tested had 6 pins, 21 pin combinations
3. 20% increase in leakage current at 1.5V denotes failure
4. The TLP test procedure is 5 positive and 5 negative pulses
   - The 21 pin combinations are tested in 25 volt increments, then device failure narrowed with 10V increments
   - Testing was stopped when leakage increased from micro to milli amps.
5. IC TLP failure voltage was used as EPI-FLO™ trigger voltage
6. MM & HBM compliance test run with EPI-FLO™ Surface Mount device in circuit

EPI-FLO Surface Mount Protects GaAs

- HBM ESD survivability of most sensitive GaAs IC pin increases from 450 to 1000 V with 80Vtrigger EPI-FLO. Less sensitive survives ten's of 2000V pulses.
- Sudden death phenomena of device is eliminated



RF Data Shows run with EPI in Module

- EPI-FLO™ is similar to a 150 – 250 fF capacitor and does not interfere with signal

EPI placed on RF out line (#592) GSM

Fin MHz	Pin dBm	Psat dBm	PsatE Eff%	Idd A	Vdd V	Vapc V	Pset dBm	PsetE Eff%	Idd A	Vdd V	Vapc V	Po2 dBm	Po3 dBm	Po4 dBm	Po5 dBm
FreqSweep															
824	0.0	34.32	51.98	1.490	3.49	2.20	33.99	50.64	1.419	3.49	1.99	-11.6	-14.3	-41.2	
836	0.0	34.66	54.41	1.540	3.49	2.20	33.99	50.74	1.414	3.49	1.92	-14.8	-13.5	-41.2	
849	0.0	34.82	55.30	1.572	3.49	2.20	33.95	50.21	1.418	3.49	1.90	-17.8	-14.3	-41.0	
880	0.0	34.91	55.70	1.595	3.49	2.20	34.03	50.74	1.429	3.49	1.89	-26.2	-19.7	-39.8	
900	0.0	34.87	55.87	1.573	3.49	2.20	33.99	51.45	1.394	3.49	1.87	-28.8	-23.3	-39.7	
915	0.0	34.81	56.22	1.542	3.49	2.20	33.99	51.79	1.387	3.49	1.88	-18.4	-26.0	-39.8	

Worst –0.2 dbm, best +0.05 dbm vs. Control → equivalent to 0.25 pf

CONTROL (#592) GSM

Fin MHz	Pin dBm	Psat dBm	PsatE Eff%	Idd A	Vdd V	Vapc V	Pset dBm	PsetE Eff%	Idd A	Vdd V	Vapc V	Po2 dBm	Po3 dBm	Po4 dBm	Po5 dBm
FreqSweep															
824	0.0	34.35	52.03	1.500	3.49	2.20	33.96	49.84	1.431	3.49	1.99	-11.3	-15.0	-40.7	
836	0.0	34.66	53.82	1.557	3.49	2.20	33.99	50.42	1.423	3.49	1.91	-15.0	-13.7	-40.5	
849	0.0	34.78	53.93	1.599	3.49	2.20	33.95	49.47	1.440	3.49	1.90	-17.8	-14.3	-40.3	
880	0.0	35.08	56.10	1.647	3.49	2.20	34.03	50.25	1.443	3.49	1.87	-26.9	-20.0	-39.8	
900	0.0	35.07	56.36	1.635	3.49	2.20	33.99	50.02	1.428	3.50	1.86	-29.6	-23.5	-39.0	
915	0.0	35.01	56.50	1.610	3.49	2.20	33.96	50.27	1.418	3.49	1.86	-19.2	-26.5	-39.2	

0.5 pf Capacitor placed on RF out line (#592) GSM

Fin MHz	Pin dBm	Psat dBm	PsatE Eff%	Idd A	Vdd V	Vapc V	Pset dBm	PsetE Eff%	Idd A	Vdd V	Vapc V	Po2 dBm	Po3 dBm	Po4 dBm	Po5 dBm
FreqSweep															
824	0.0	34.50	53.95	1.496	3.49	2.20	34.03	51.85	1.398	3.49	1.94	-11.5	-13.3	-41.2	
836	0.0	34.73	55.60	1.530	3.49	2.20	33.98	51.51	1.393	3.49	1.89	-14.3	-12.8	-40.7	
849	0.0	34.82	56.09	1.550	3.49	2.20	33.95	50.89	1.399	3.49	1.88	-16.8	-13.5	-40.7	
880	0.0	34.95	57.89	1.547	3.49	2.20	33.99	51.87	1.386	3.49	1.86	-25.4	-18.3	-40.3	
900	0.0	34.73	56.26	1.512	3.49	2.20	33.98	53.05	1.352	3.49	1.85	-23.6	-21.8	-39.8	
915	0.0	34.67	56.97	1.474	3.49	2.20	34.03	53.46	1.355	3.49	1.88	-16.2	-24.5	-39.5	

Worst –0.4 dbm, best +0.1 dbm vs. Control

Embedded EPI-Core Reliability Testing

EPI-FLO™

- Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Devices (IPC/JEDEC J-STD-020C)
- Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing (JESD22-A113D)
- Thermal Shock (JESD22-A106B)
- High Temperature Storage Life (JESD22-A103C)
- Low Temperature Storage Life (JESD22-A119)
- Steady State Temperature Humidity Bias Life Test (JESD22-A101-B)
- Accelerated Moisture Resistance–Unbiased Autoclave (JESD22-A102-C)
- Peel Strength of Metallic Clad Laminates (IPC-TM-650 2.4.8)
- Solderability (JESD22-B102D)
- Power and Temperature Cycling (JESD22-A105C)
- Temperature, Bias and Operating Life (JESD22-A108-B)

Embedded EPI-CORE Advantages

EPI-FLO™

- Frees up surface space on the PCB allowing either a smaller footprint or more devices thereby increasing performance
- ESD protection is directly under the IC to be protected
- Multiple pins and pin combinations are simultaneously protected
- There is no cost for solder joints, inspection and unused PCB
- ESD cost on a per signal line basis is much, much less and therefore affordable
- ESD protection can be continually improved to provide superior reliability

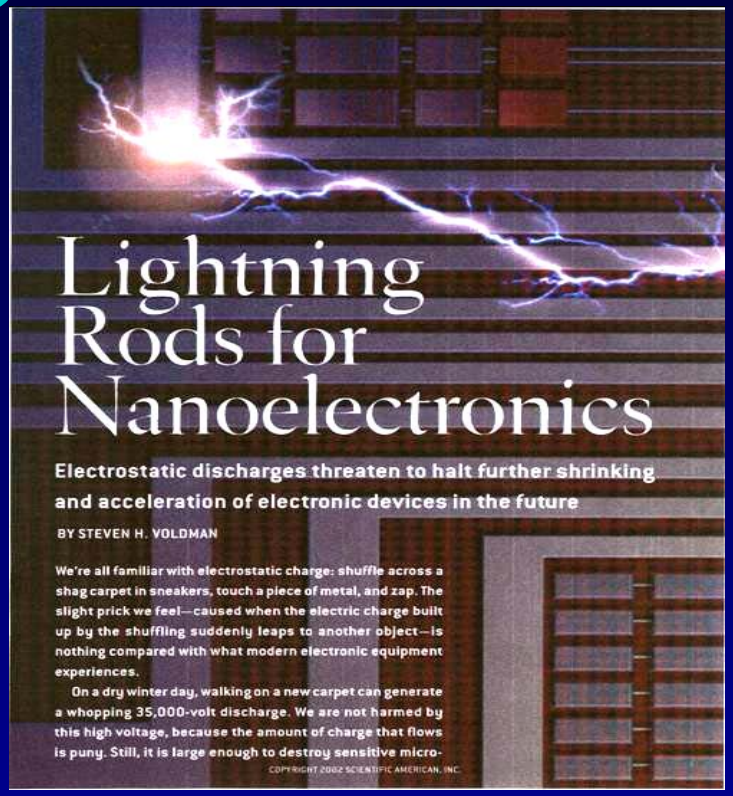
Embedded Passives: The Next Revolution

EPI-FLO™

- The National Electronic Manufacturers Initiative is to reduce the # of passives on the board by embedding them in the board
- As functionality increases, the number of ICs and passive components increases dramatically.
- All this leads to the fact that the size of a device is now becoming more often a function of the circuit board or module size than anything else.
- **The question** becomes therefore, how will all these future features be contained in products that will still fit in your hand?
- **The answer** may very well be the elimination of the passive component on the surface of the circuit by burying them within the inner layers of the printed wiring board.

EPI-Cores fit right in with resistor and capacitor embedded roadmap

In 2002 Voldman Viewed ESD as a Roadblock to Moore's Law



EPI Offers ESD Solution:" It is contemplated that in the future, PVS films can replace the current usage of on-chip protection, opening up new markets, obtaining improved ESD protection for GaAs, magnetic recording industry, and even better ESD results for the 100 to 200 GHz Silicon Germanium heterojunction bipolar technologies."

"Electrostatic discharges threaten to halt further shrinking and acceleration of electronic devices in the future"

Steven H. Voldman IBM (holder of over 150 patents) in October 2002 Scientific American

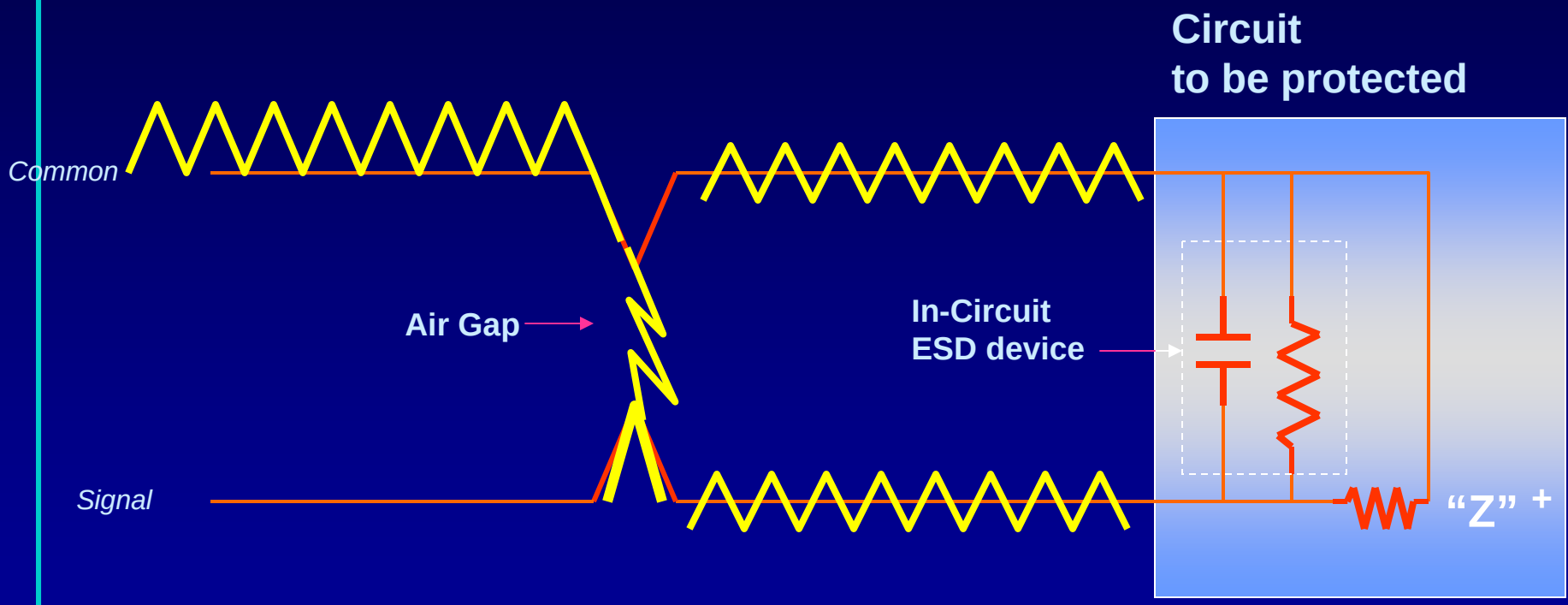
Summary

- Embedded EPI-Cores are an emerging technology for ESD protection in IC packages and PCB that meets both NEMI and ESDA Technology Roadmaps
- EPI-FLO™ protection of GaAs demonstrates the potential for removing ESD as a potential barriers to Market entry for sensitive semiconductors
- Currently in process on embedded EPI-Core is:
  - Manufacturing Qualification and Artwork design rules
  - Manufacturing Readiness at Subcontractors

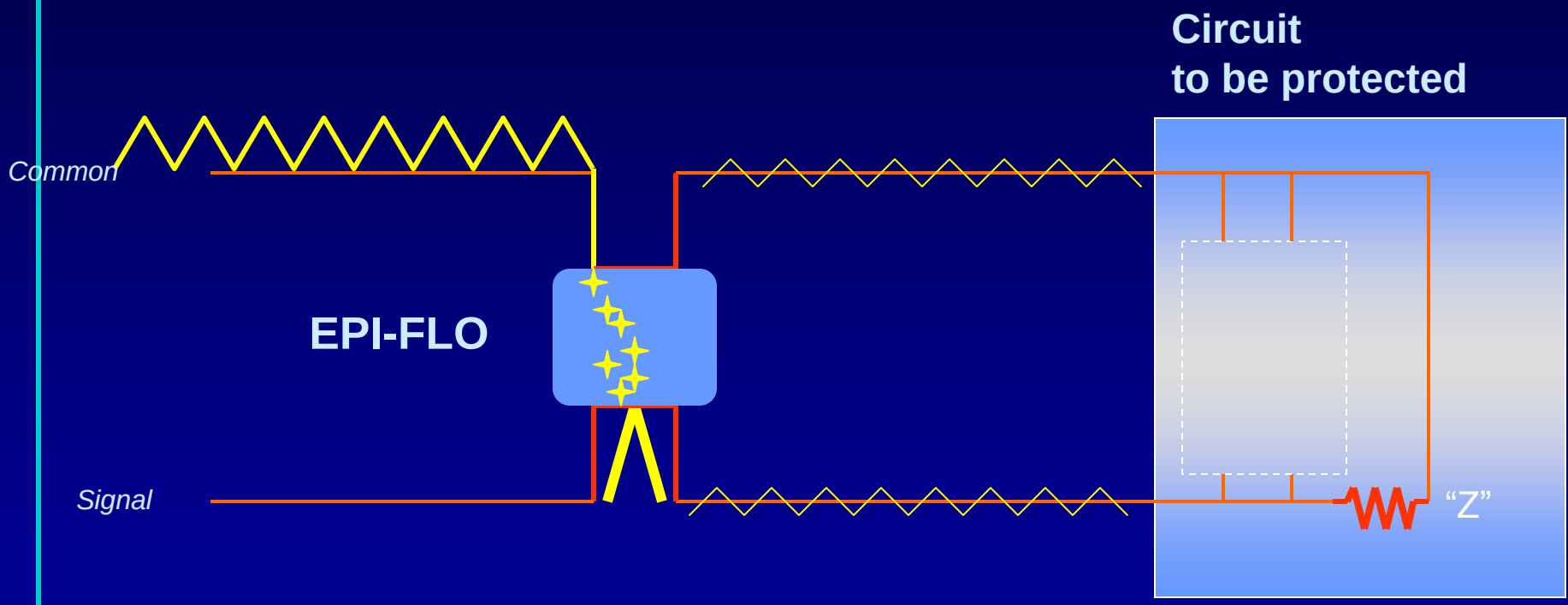
Embedded EPI-CORE $ advantages combined with the opportunity to increase product function and reliability is in our view an exciting and challenging opportunity for EPI customers. **Thank you…Go with the FLO, EPI-FLO™**

Air Gap based ESD protection

EPI-FLO ™

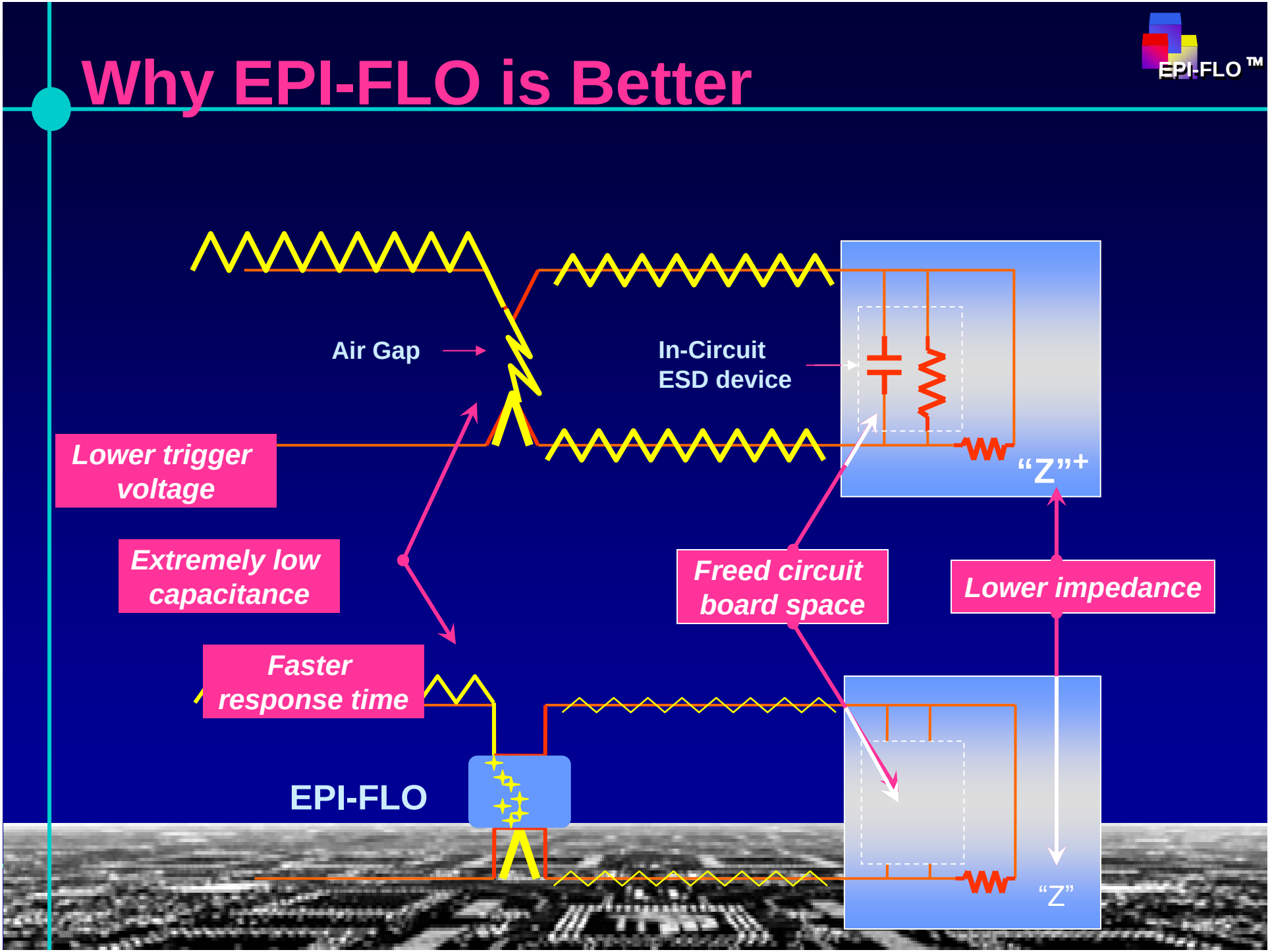


EPI-FLO based ESD protection

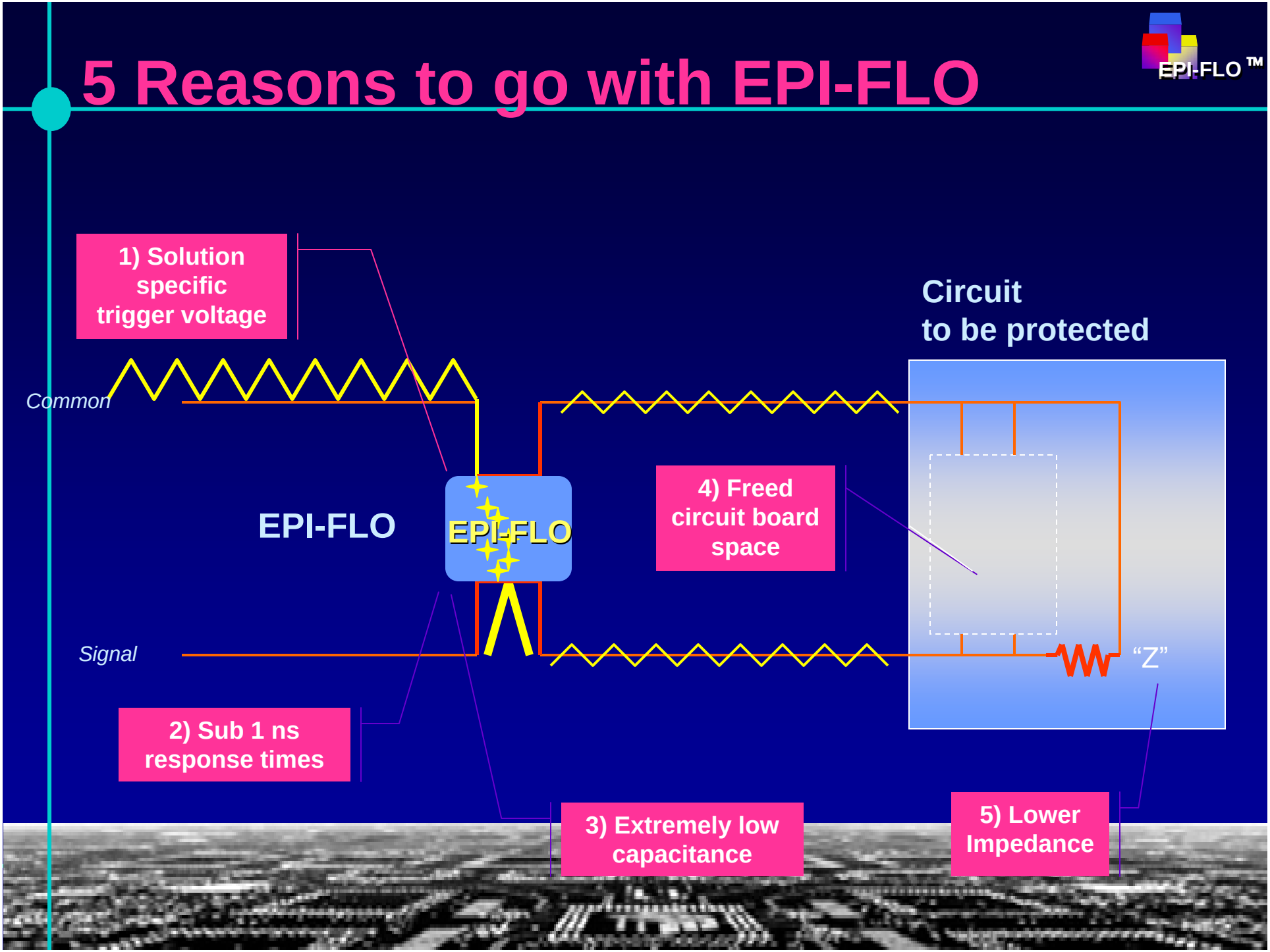


Why EPI-FLO is Better

EPI-FLO ™



5 Reasons to go with EPI-FLO



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The next wave in ESD protection