

Ionization Basics

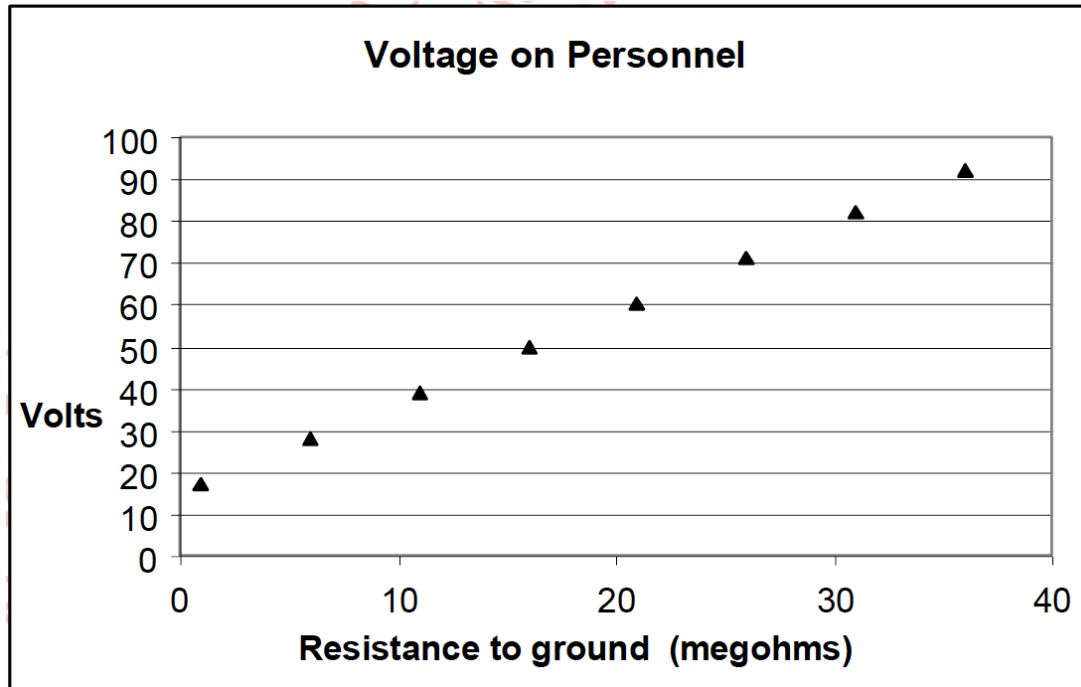
We Know **ESD**TM

We provide ESD control, not just solutions!

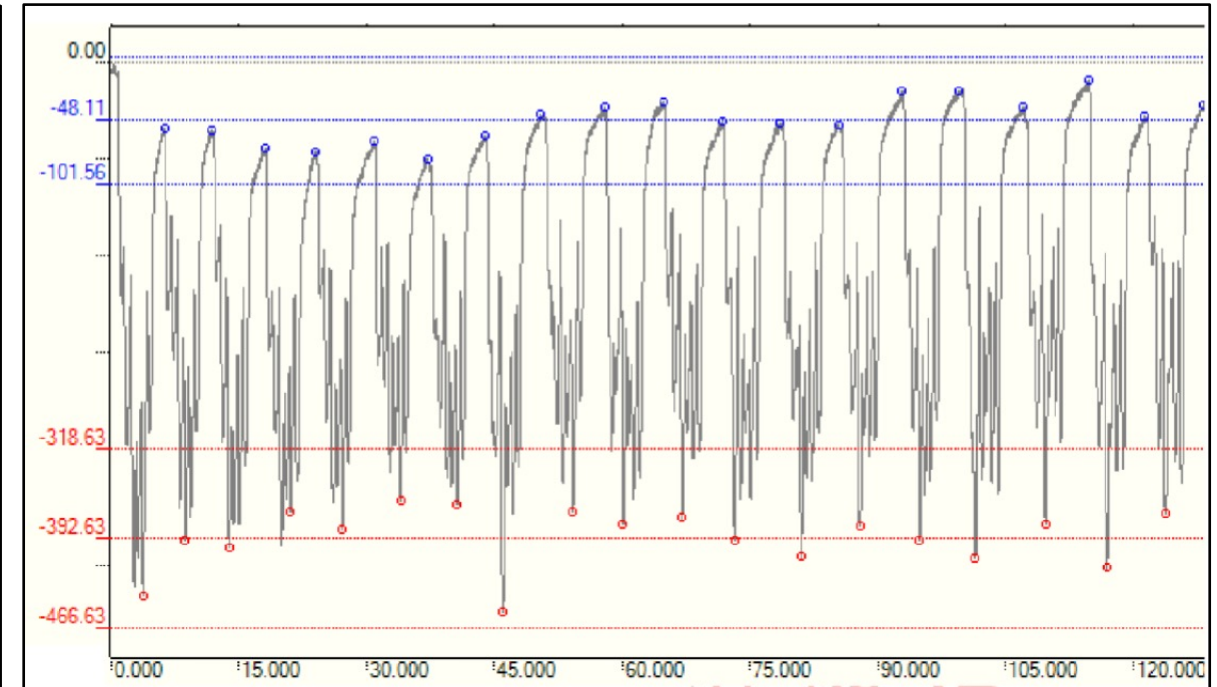
- ESD Control Strategy: HBM & CDM
- Ionization Operation Theory
- Type of Ionizers
- Ionizer Measurement Instruments and Related Standard Documents
- Future Challenges
- Transient Noise from Ionizers

HBM Control Strategy

- ANSI/ESD S20.20-2021 control scope is 100V HBM and this can achieve by limiting body voltage less than 100V - Personal Grounding



Relationship Between Body Voltage and Resistance to Ground.
Wearing Wrist Strap with Standard Shoe on a non-ESD Flooring



Determining Process Capability of a Footwear/Flooring System
using ANSI/ESD STM97.2

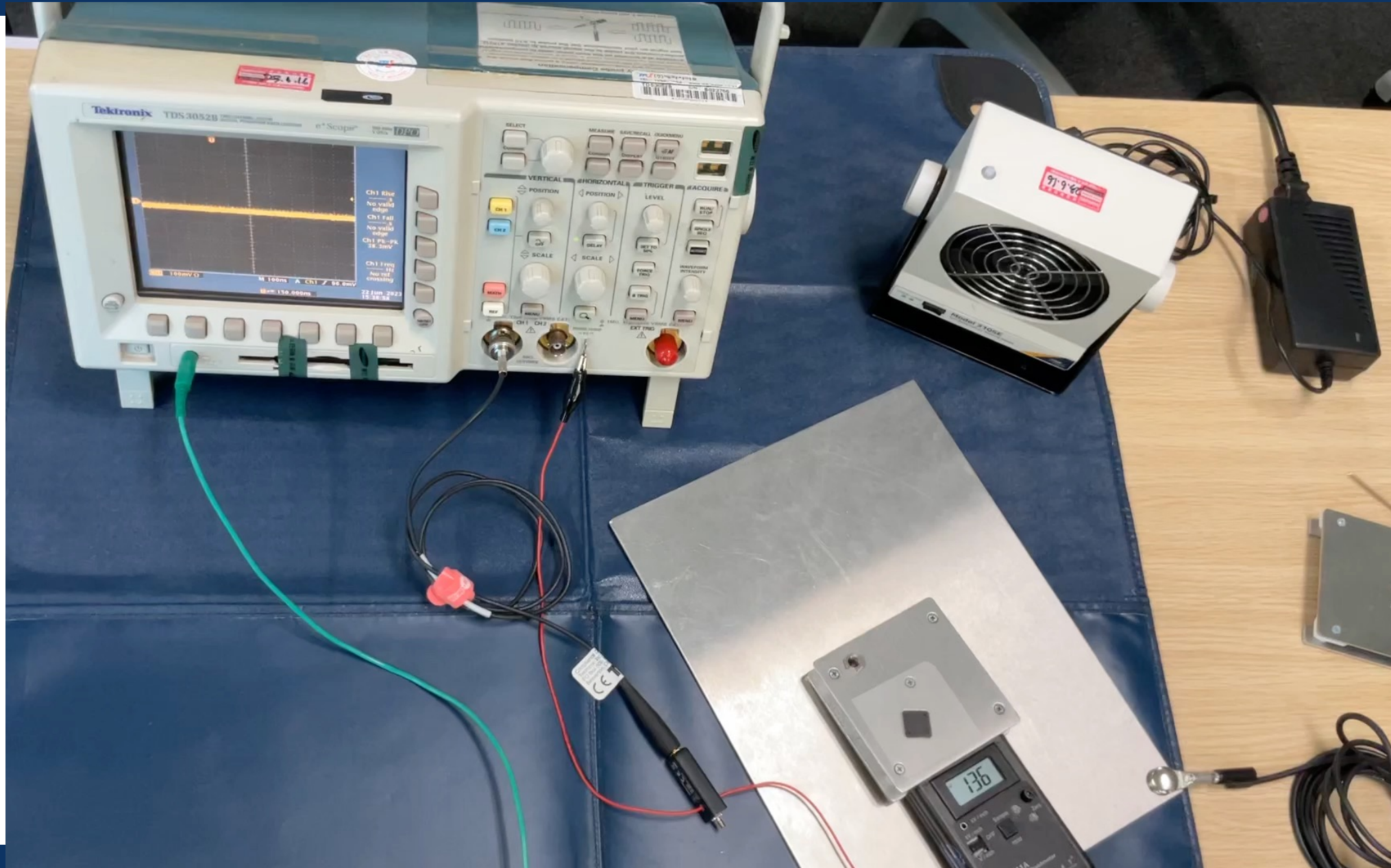
Ohm's Law

$$V = IR$$

$$\downarrow I = \downarrow V / R \uparrow$$

Contact Resistance Safe Range Optimization! (Increase)
Reduce **Voltage (Charge)** on Device!

Ionization Effectiveness Demo Video



- Non-Electrical Ionizations

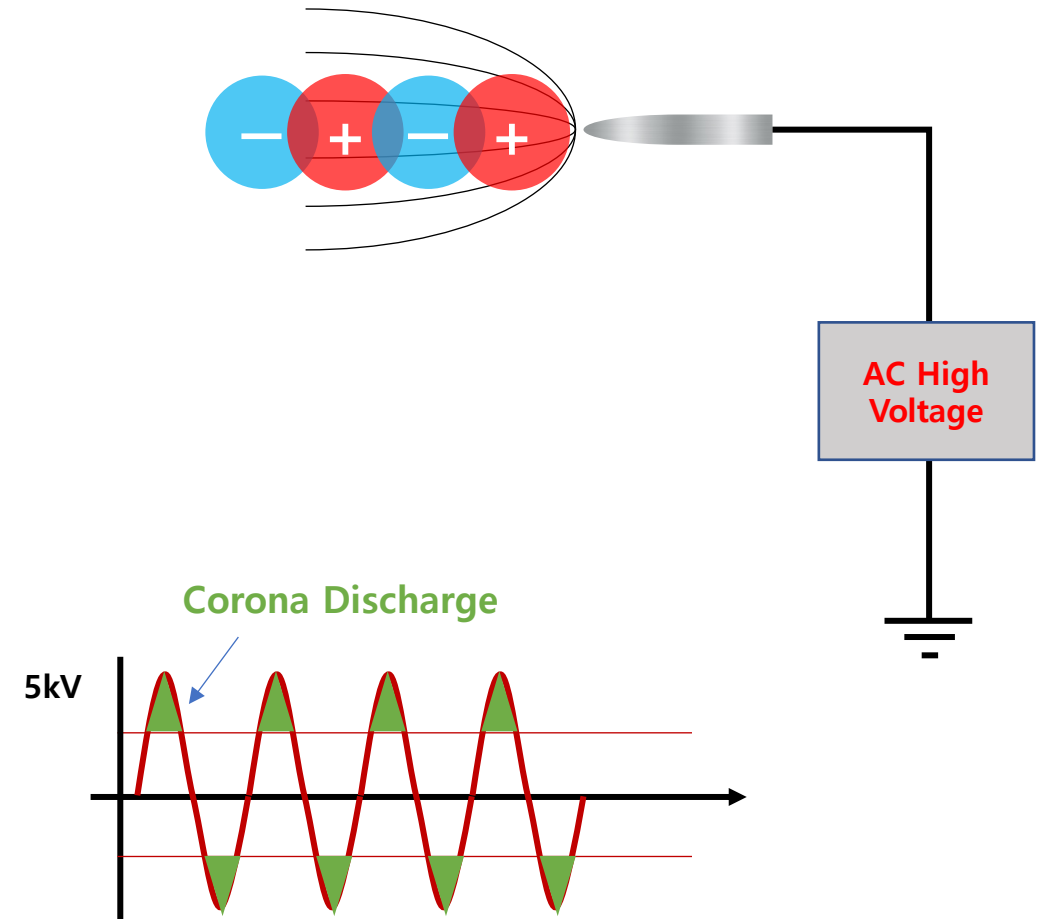
- Photon – Soft X-ray
- Nuclear – Alpha
 - Ultra Low Offset Voltage
 - **Shielding** Environment or Inside of Process Tool with Interlock System
 - **Government Controls**
 - License and Documentation
 - Regular Reports
 - **Cleanroom Compatible**
 - No Particles Shedding
 - Air Assist: Nuclear
 - Non-Air Assist: Soft X-ray
 - Still need **maintenance** for Leakage and Decay Time performance

- Electrical Corona Discharge

- High Voltage Power Supply
- Ion Emissions Type
 - Conventional AC
 - Steady-State DC
 - Pulsed DC
 - Pulsed AC
 - High Frequency AC
- **Measurement**
 - Peak Offset Voltage & Decay Times
- **Cleanroom Compatibility**
 - Cleanliness Requirements
 - Emitter Points Materials - Particle Shedding – Very Small
 - Cleaning Cycles
- **Maintenance**
 - Fuzz Balls are maintenance issue

- Conventional AC Ionizers

- High Dense of Electric Field on Emitter Point
- 50/60Hz, 4 - 7 kV Fixed AC HV
- Configurations
 - Single Emitter Point on Nozzle
 - Multi Emitter Points on Bars
 - Air Assist or Non-Air Assist
- Ion Recombination from Same Source
- Induction Field: More than 300 mm distance
- Applications
 - ESD control at long distance or CDM Robust Device Handling
 - Industrial Web and Roll-to-Roll Static Control for Paper and Films



Ionization Technology: Corona Discharge - AC

- Conventional AC and Pulsed AC Bar Ionizers

Air Knife
Bar Ionizer



5kV Fixed
High Voltage
AC Transformer



3 - 7kV Output Adjustable
Pulsed AC Bar Ionizer



Shockless Type
Bar Ionizer



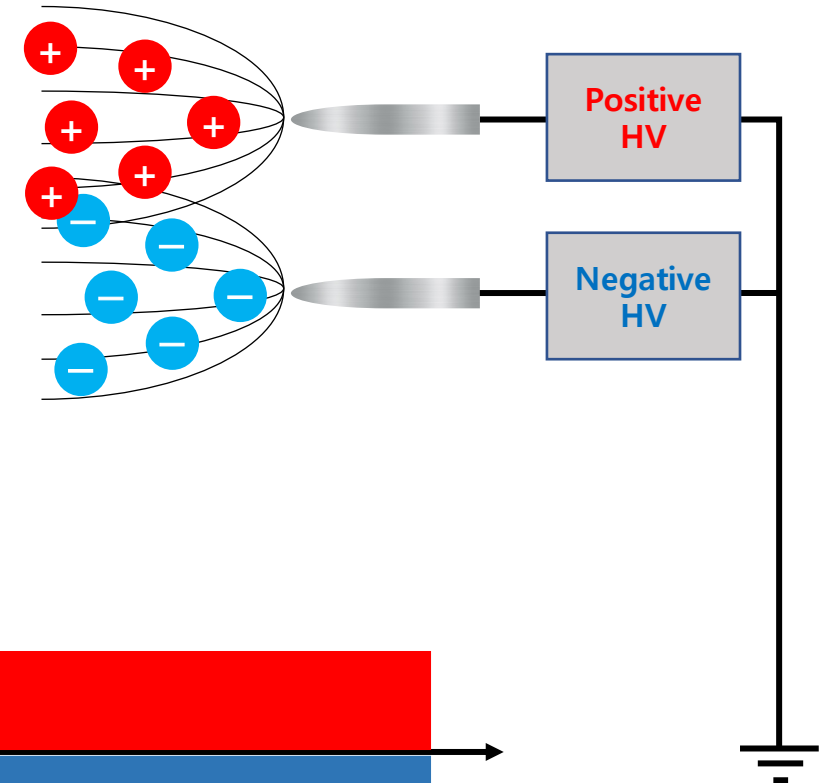
3 - 7kV Output
Adjustable
Pulsed AC Power Unit

- **Conventional DC Ionizers**

- High Dense of Electric Field on Emitter Points
- **Individual DC Power Supply:** Pos + Neg
- Configurations
 - Pairs of Emitter Points: 4 or 8
 - Mostly Fan Blowers
- **Lower Ion Recombination**
- **No Induction Field:** Less than 300 mm distance
 - Offset Voltage, Stability and Polarization

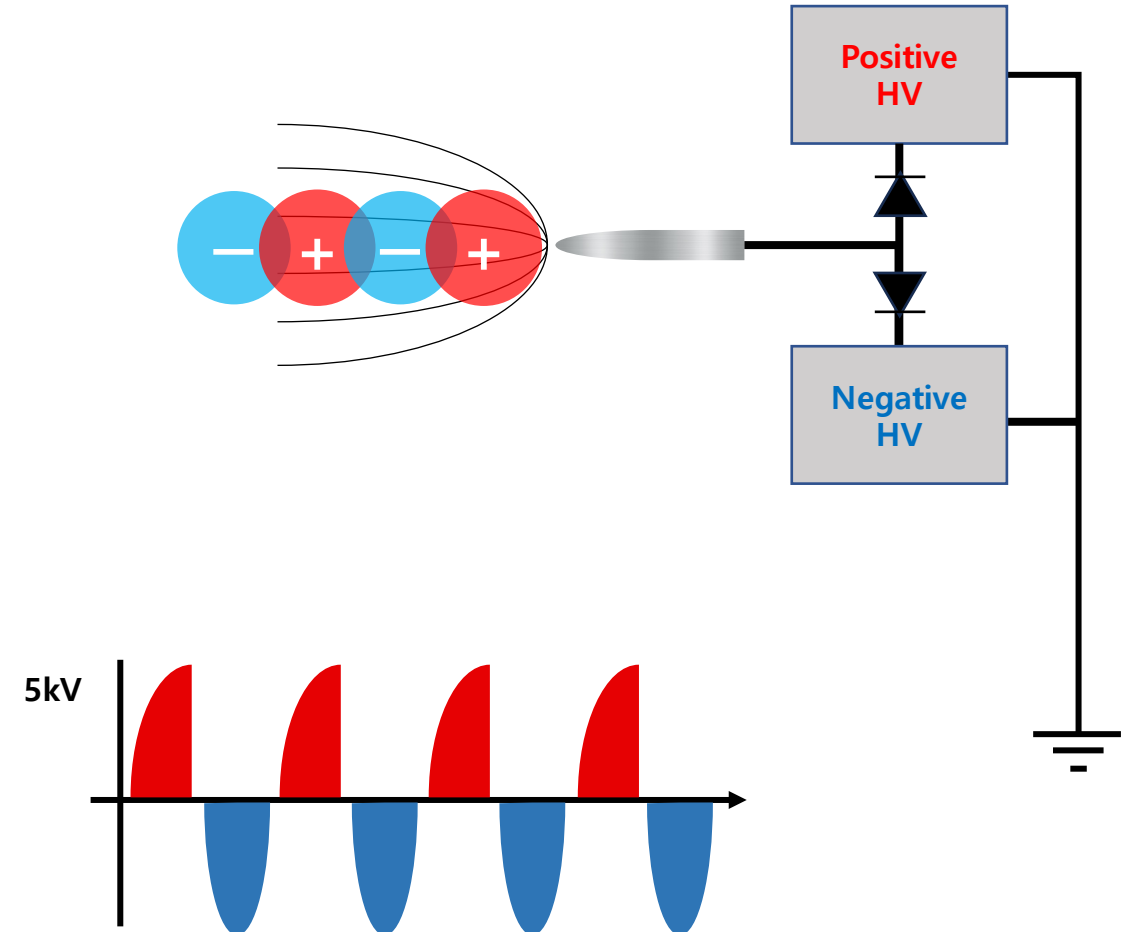
- **Applications**

- ESD Control Relatively Short Distance for General CDM Sensitive Device
- Fan Blowers are not recommended for contamination control



- Pulsed AC Ionizers

- High Dense of Electric Field on Emitter Points
- Output Adjustment
 - Voltage, Frequency and Duty Cycle
 - 3 - 7 kV, 10 - 100 Hz, 50 - 100%
- Configurations
 - Multi Emitter Points on Bars
 - Air Assist or Non-Air Assist
- Ion Recombination from Same Source
- Induction Field: More than 300 mm distance
- Applications
 - Static Control for Flat Panel Display
 - Clean Dry Air



CoreStat® Self-Balanced Air Ionizing Blowers



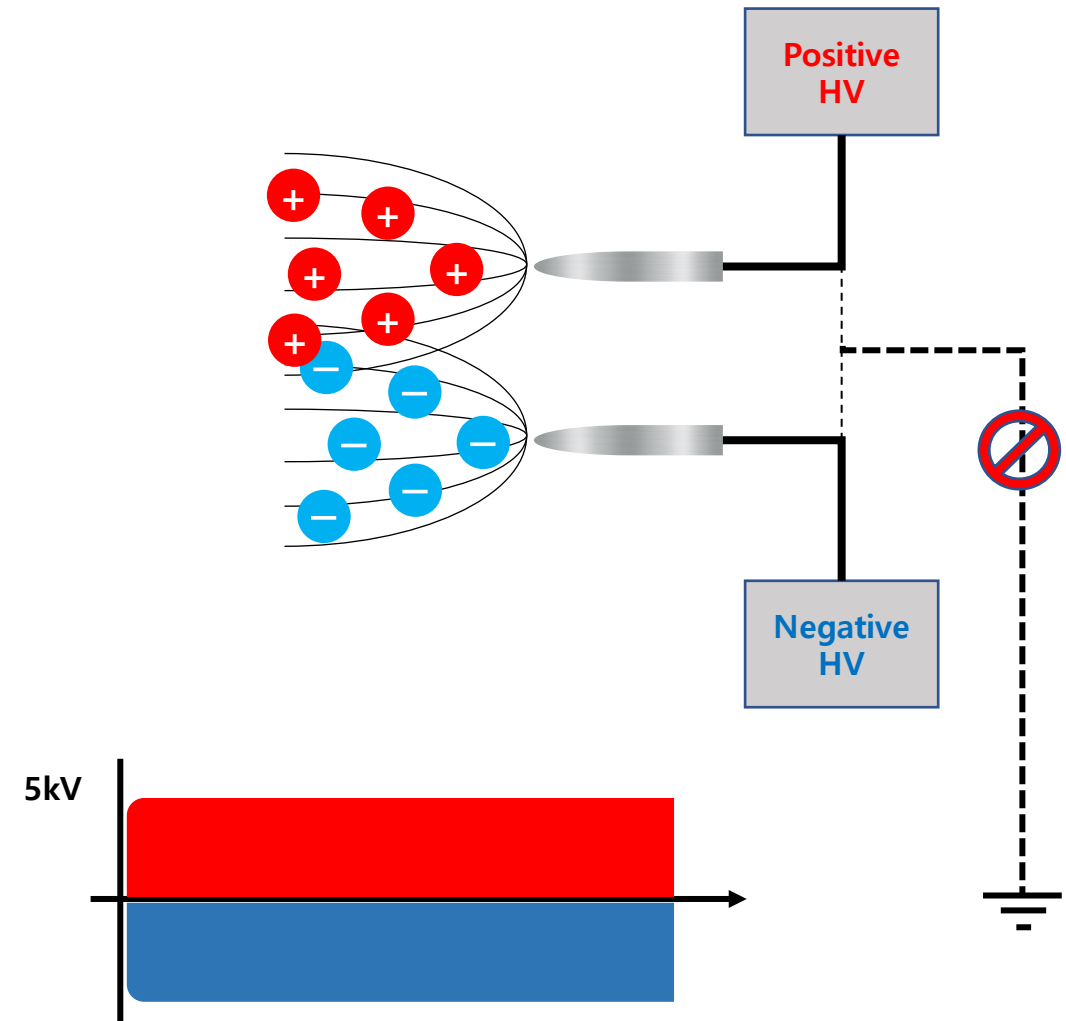
Ionization Technology: Corona Discharge - Steady State DC

- 18 month stayed in House of Horse
 - Ion Balance: Less than 10 volts
 - Decay Time: Less than 3 seconds at 300mm distance. It was less than 2 seconds.



- **Steady-State DC Ionizers**

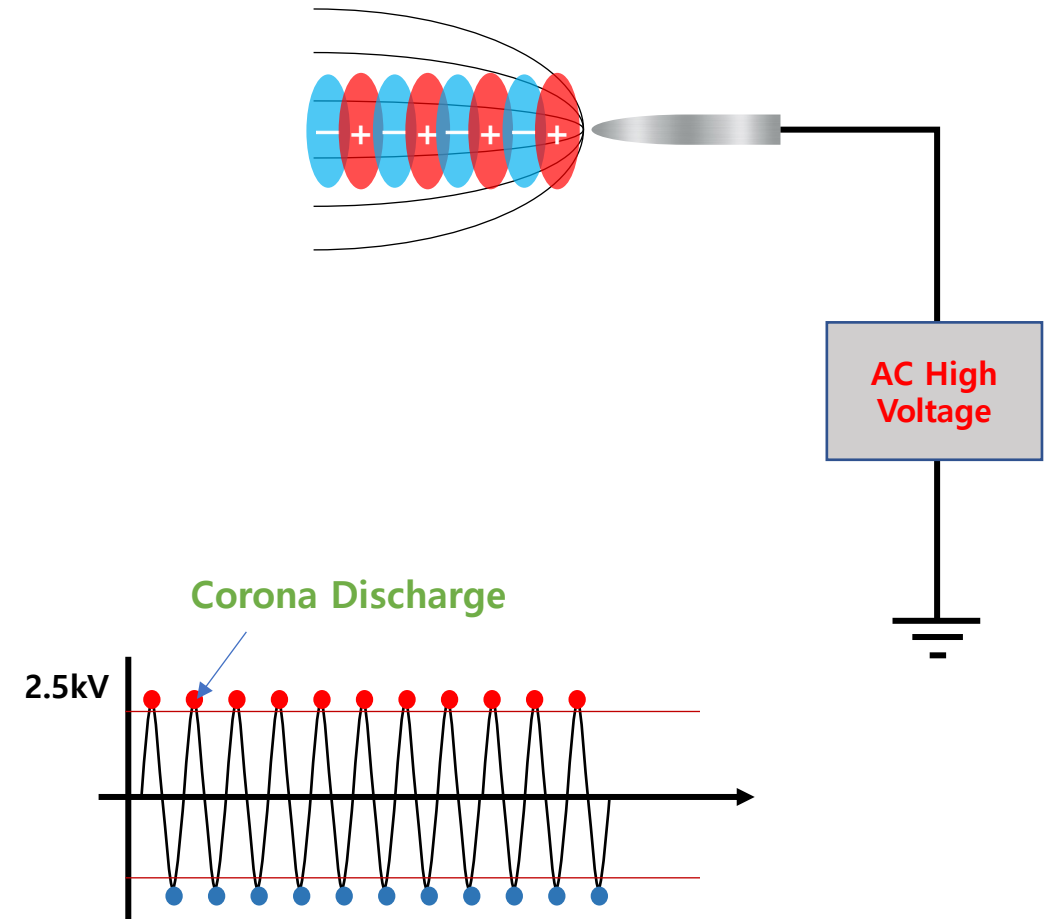
- High Dense of Electric Field on Emitter Points
- Electrically Bonded Equilibrium Technology
 - No Electrical Ground Required and Reference Opposite polarity
- Intrinsic Self-Balance Maintenance
 - Less than 10 V or 5 V
- Lower Ion Recombination
- No Induction Field: At 25 mm distance
 - Very Low Peak Offset Voltage
- Applications
 - ESD Control for **Automated Handling Equipment (AHE)** for Class 0 controls
 - Fan Blowers are not recommended for contamination control



Ionization Technology: Corona Discharge - Steady State DC



- High Frequency AC Ionizers
 - Piezo Crystal Power Sources
 - High Frequency AC: 16 - 70kHz
 - Configurations
 - Single Emitter Point on Nozzle
 - Multi Emitter Points on Bar & Blowers
 - Air Assist Required
 - **Advantages:** Small Formfactor & Space Limited
 - **Maintenance**
 - Emitter Cleaning Cycle: Every Week
 - **Applications**
 - General Electronics
 - Ozone Limit: 0.5 ppm



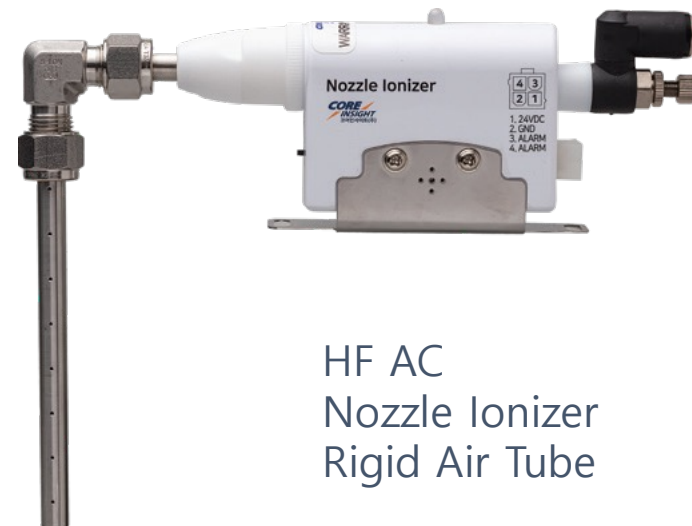
Ionization Technology: Corona Discharge - High Frequency AC



HF AC
Nozzle Ionizer



HF AC
Nozzle Ionizer
IR Detector



HF AC
Nozzle Ionizer
Rigid Air Tube



HF AC
Nozzle Ionizer
Air Hose

**Particle Removable
Application***



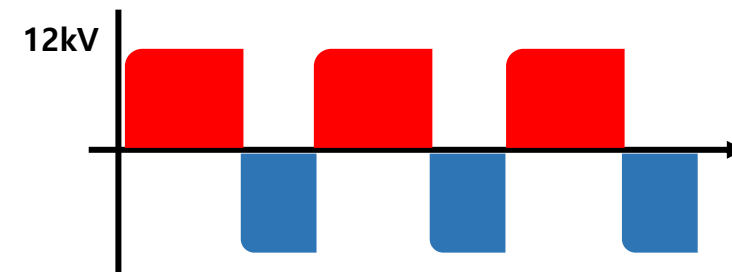
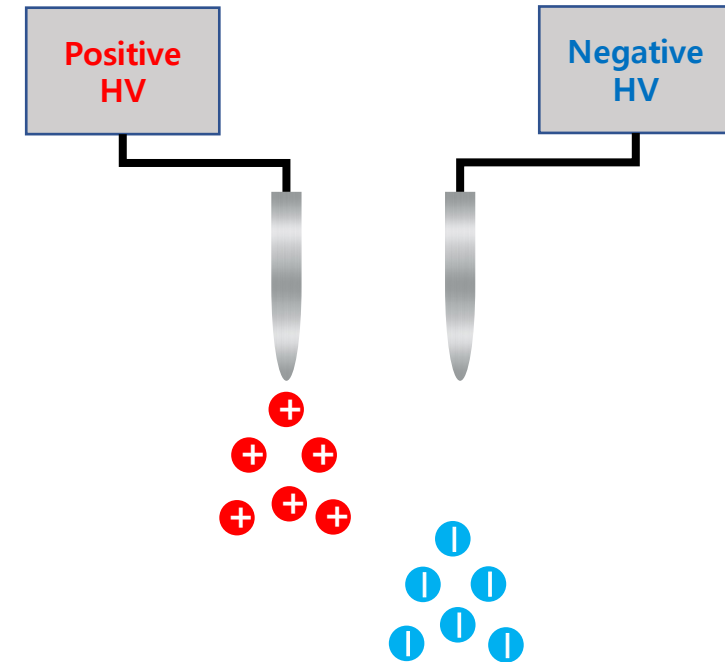
ESD Control Application*



HF AC
Nozzle Ionizer
with Air Tube + Fixtures

- Pulsed DC Ionizers

- Cleanroom Contamination Control
- Individual DC Power Supply: Pos + Neg
- Configurations
 - Pairs of Emitter Points
 - Clusters of Ceiling Emitters
- Very Low Ion Recombination
- Induction Field: Longer than 1000 mm
 - Pulse Stability, Uniform Coverage
- Applications
 - Not ESD Control, Particle Contamination Control: 100 - 150V Swing Voltage
 - Fan Blowers are not recommended to adopt this technology

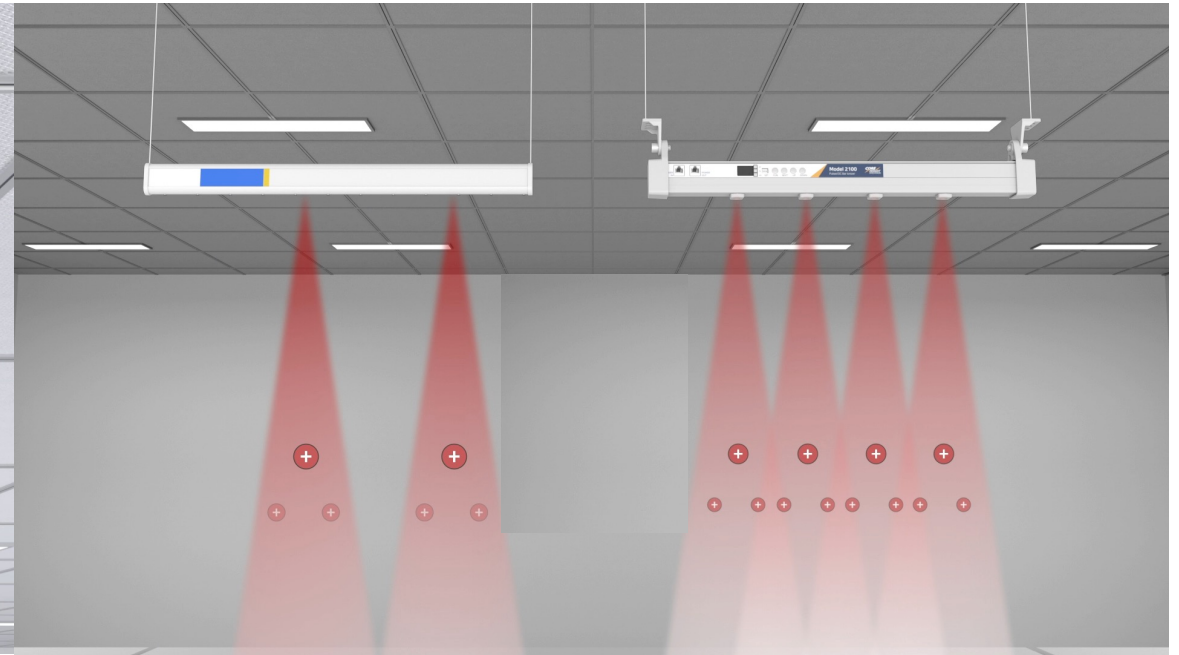


- Room Ionization System



- Laminar Flow
- Ceiling Height Installation

- Workstation: Bar Ionizers



- Laminar Flow
- Workstation Height Installation

Ionization Technology: Corona Discharge - Pulsed DC



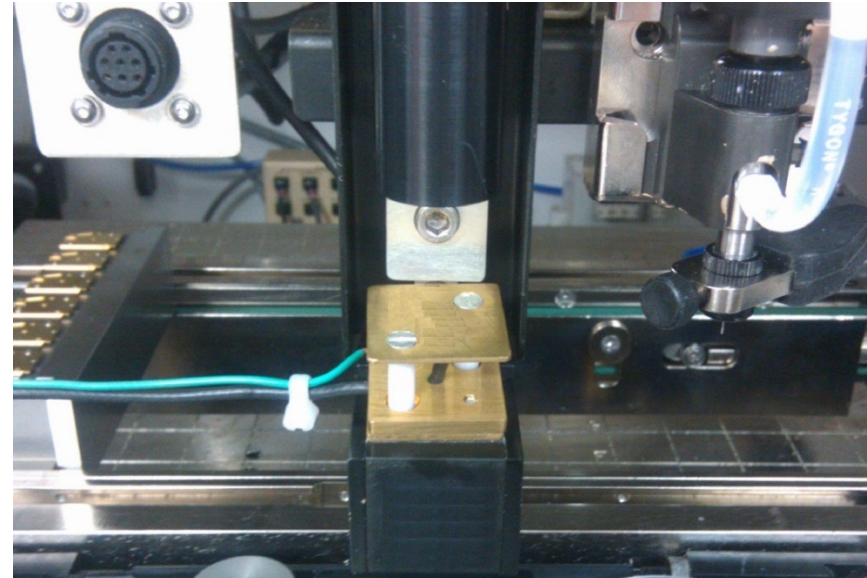
- ANSI/ESD STM 3.1
 - Product Qualification Document
 - No Requirement for Humidity and Temp.
 - Test Set-up: Static Dissipative Surface
 - Test Point: 1 - 12 points
- CPM Plate and Instrument
 - 20pF $\pm$ 2pF, 15 x 15 cm Plate
- Offset Voltage (Balance) Test
 - ANSI/ESD S20.20 < $\pm$ 35V
- Decay Time Test
 - Time for +1000V to +100V
 - Time for -1000V to -100V



- ANSI/ESD SP 3.3 & TR53
 - Compliance Verification Document
 - Simple: Meet the Requirement or Not
 - Test Set-Up: Actual Distance & Height
 - Test Point: 1 point
- Measurement Instrument
 - CPM or Functional Instruments
 - Smaller Capacitance Available, Timer
- Offset Voltage (Balance) Test
 - ANSI/ESD S20.20 < $\pm 35V$ or Requirement
- Decay Time Test
 - Time for +1000V to +100V
 - Time for -1000V to -100V

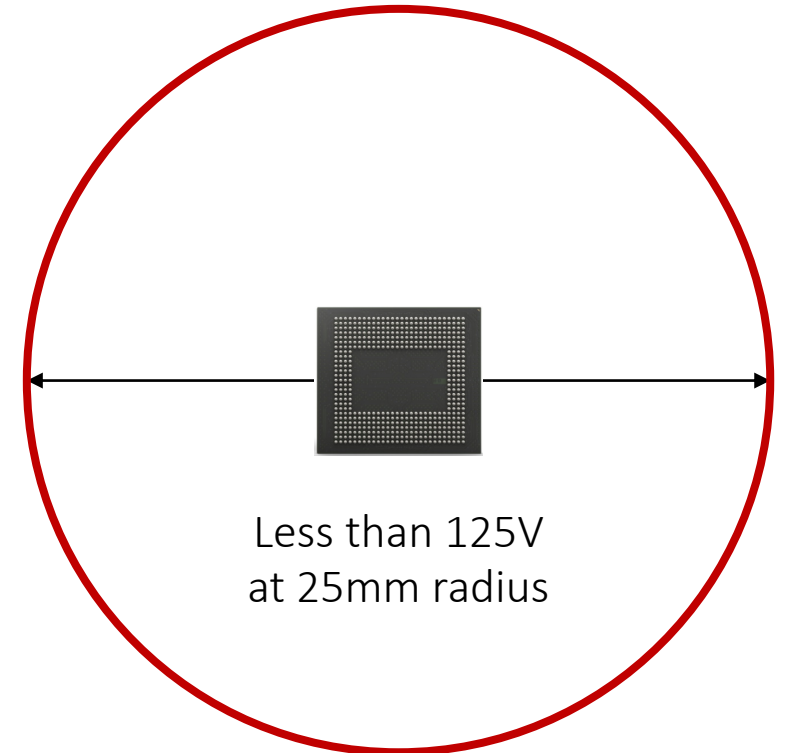


- ANSI/ESD SP 3.4
 - Compliance Verification Document
 - Small Test Fixtures
 - Test Set-Up: Actual Distance & Height
 - Test Point: 1 point
- Measurement Instrument
 - CPM or Functional Instruments
 - Smaller Capacitance: Approximately 3pF, Different Offset Voltage and Decay Time
- Offset Voltage (Balance) Test
 - ANSI/ESD S20.20 < $\pm 35V$ or Requirement
- Decay Time Test
 - Time for +1000V to +100V
 - Time for -1000V to -100V



ANSI/ESD S20.20-2021 Requirements

- ANSI/ESD S20.20-2021 and IEC 61340-5-1 ESD Control Program
- Scope: HBM 100V and CDM 200V by induction field control
- CDM Control: Process Essential Insulator should be **less than 125V at 25mm distance** to ESDS item by non-contact voltmeter or fieldmeter
- Isolated Conductor should be **less than 35V** by non-contact voltmeter or contacting voltmeter measurement - Related with Ionizers
- **Automated Handling Equipment (AHE)** are required by SP17.1 Process Assessment



ANSI/ESD S20.20-2021: Ionization

- ANSI/ESD S20.20-2021 has added a **one word** for ion balance measurement should take '**Peak**' offset voltage of ionizers, not just random voltage.
- Offset voltage is **not average** and should take '**Peak**' voltage of ionizers

ANSI/ESD S20.20-2021

Technical Requirement	ESD Control Item	Product Qualification		Compliance Verification	
		Test Method	Required Limit(s) ⁽⁸⁾	Test Method	Required Limit(s)
	Ionization	ANSI/ESD STM3.1	Discharge Time User-defined	ESD TR53 ⁽¹¹⁾ Ionization Section	Discharge Time User-defined
			Offset Voltage (Peak) -35 volts < Voffset < 35 volts		Offset Voltage (Peak) -35 volts < Voffset < 35 volts

White Paper 2: CDM Target Level

- A CDM level of 250 volts had been introduced in 2009. As the roadmap further projects, **at the 7nm node and beyond, 125 volts** is proposed as a new practical CDM level for ultra-high-speed interfaces between 56 Gb/s and 224 Gb/s.

Apple M1 Pro
Incredible performance for pro applications

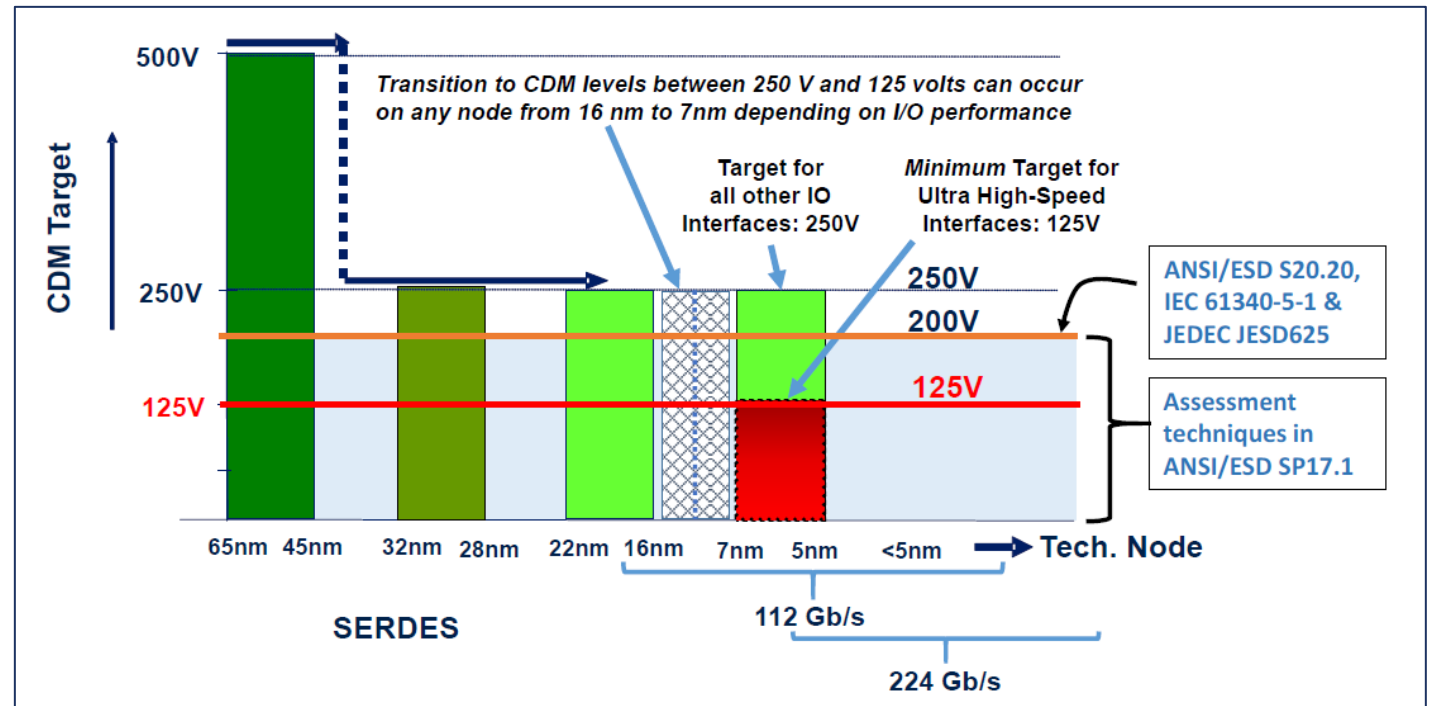


Up to
9x faster
graphics performance⁴

Over
200GB/s
memory bandwidth

**Supports two
external displays**

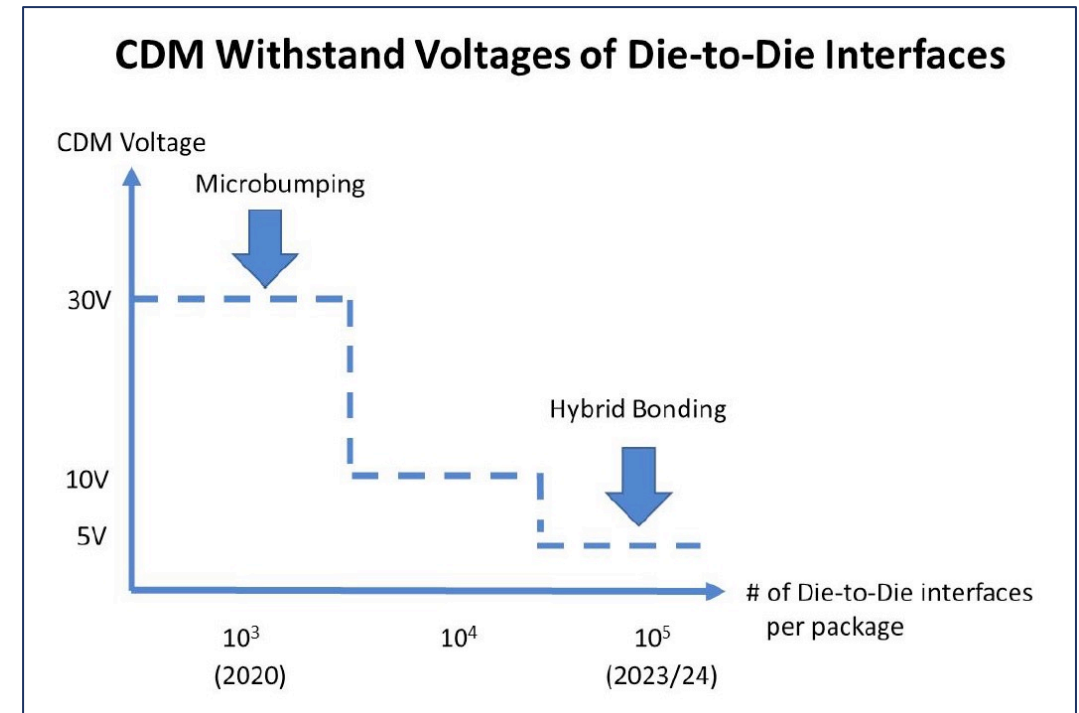
Courtesy of Apple, Inc.



ESD Industry Council, White Paper II. Rev. 3, May 2021

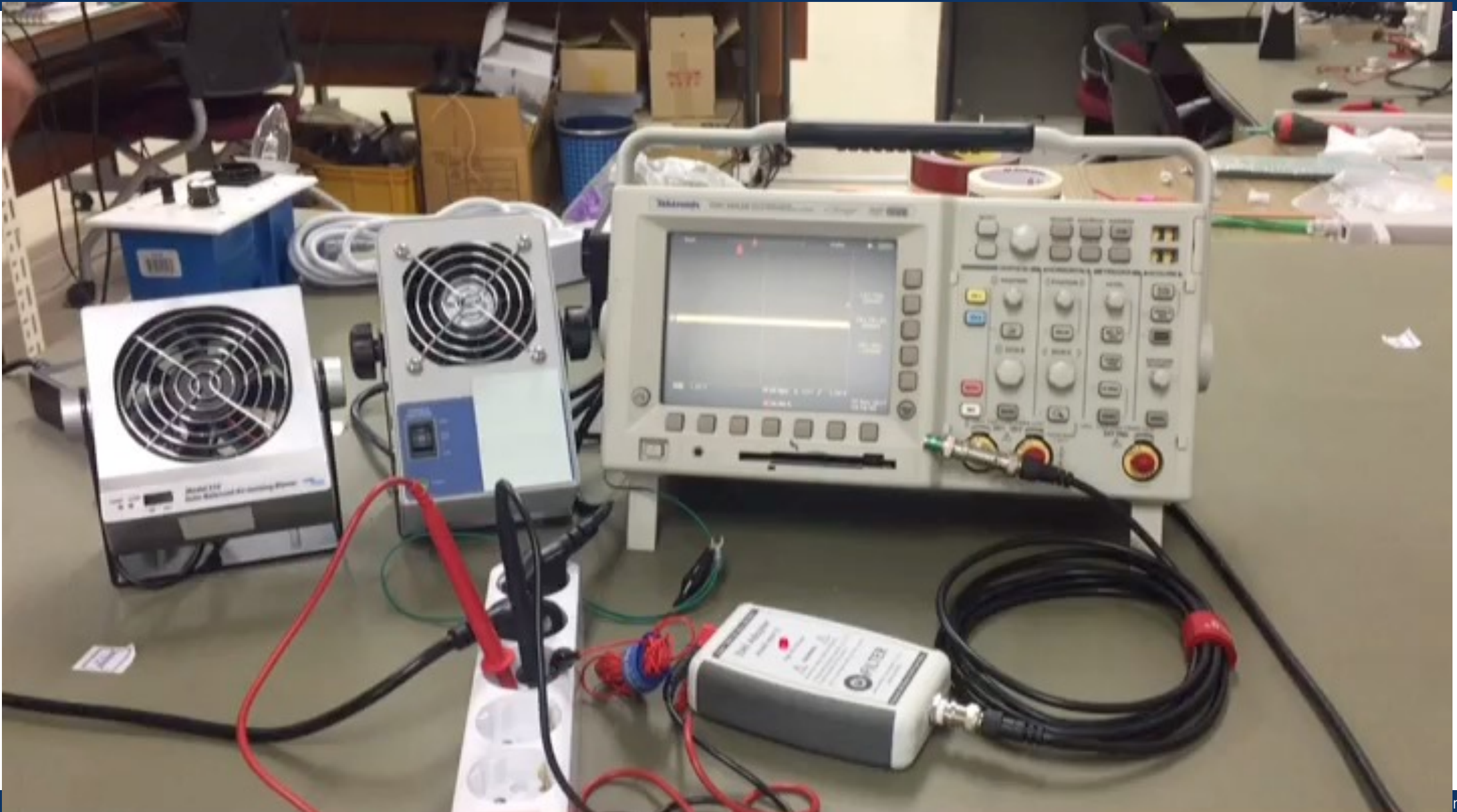
2.5D and 3D IC Manufacturing ESD Challenges

- This need to **decrease** when entering the regime of extensive heterogeneous integration based on **hybrid bonding** which leads to tens of thousands of die-to-die interfaces/mm² up to 1 million die-to-die interfaces/mm².
- To avoid an exponential increase in ESD related chip area and power, the robustness target for **CDM die-to-die interface needs to drop to < 5 volts** while improving the ESD control of the process and handling steps of heterogeneous integration



ESD Industry Council, White Paper II. Rev. 3, May 2021

Transient Noise from Ionizers



Questions?

