2016 EOS/ESD Symposium

Dummy Versus Live ESD Sensitive Devices Charge Analysis for Automated Handling Equipment ESD Qualification

针对自动化处理设备ESD认证，比较和分析虚拟以及实际ESD敏感产品生成的静电

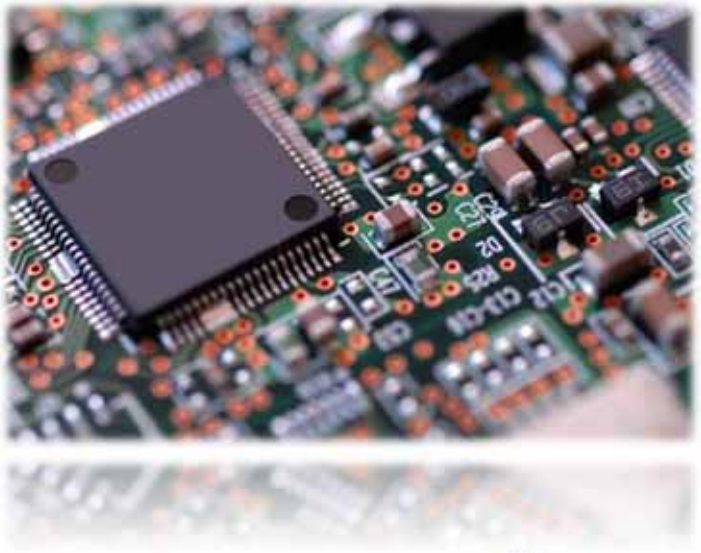
Technical Presentation #3
18th November 2016, Xi'an, China

Jeremy Ong 王伟光(1), Bernard Chin 陈孟勇 (1), Yohan Goh 吴耀汉 (2), L.H. Koh 许良海博士(2)

(1) UTAC联合科技(股份有限)公司
(2) Everfeed Technology Pte Ltd

Outline

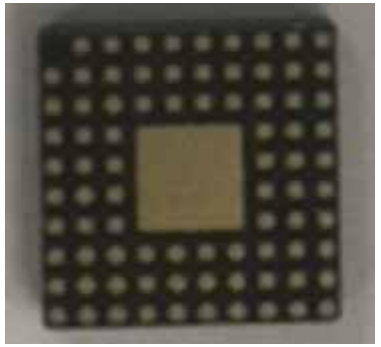
1. Introduction - 介紹
2. Methodology - 实验方法
3. Results - 结果
4. Discussion - 讨论
5. Conclusion - 结论
6. Acknowledgement - 鸣谢
7. References - 参考



1. Introduction

- Automated Handling Equipment (AHE)
  自动化处理设备 (AHE)
  – ANSI/ESD SP10.1

- Dummy ESD sensitive devices (dummy units)
  ESD敏感的虚拟样品
  – Cost
  成本
  – Limited availability of live units
  实际产品有限



1. Introduction

- In industry practice, 实际工业应用
- Dummy units stored in non-dry cabinet

  虚拟样品存储在非干燥柜

  - Rh 50% +/- 3%

  - 23°C +/- 2°C

  - Stored more than 72 hours (3 days)

  – Live units are used for testing within 24 hours of baking

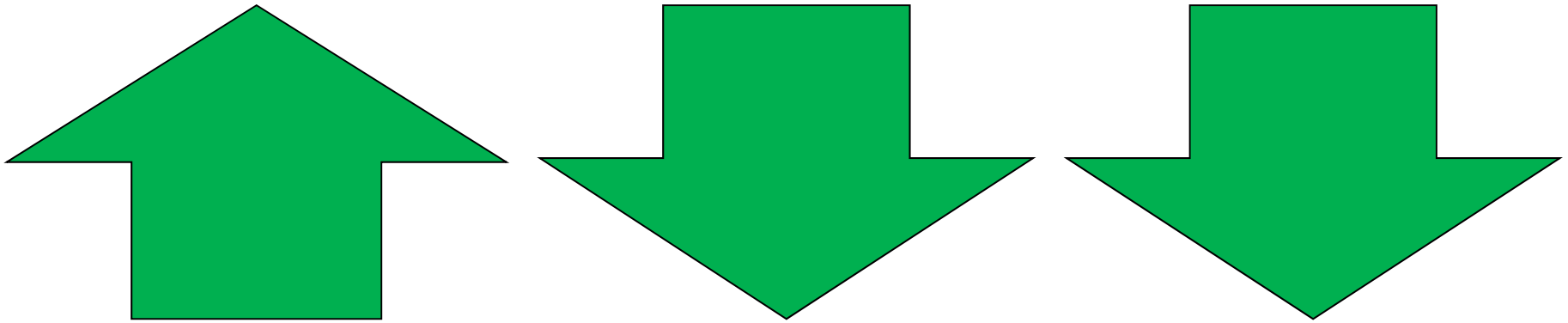
    实际产品在烘焙后24小时内, 用于实验

1. Introduction

- If the dummy units are representative of the live units, then the AHE can be qualified as ESD safe

如果虚拟样品可以代表实际产品，则AHE可以被认定为ESD安全。

- Leads to:

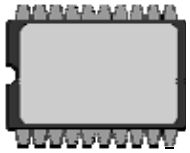


AHE Utilization Hours
AHE 优化使用时间

Production Time
生产时间

Production Cost
生产成本

2. Methodology (Experiment 1 & 2)



- 84 pin fcLGA 10x10 package
- 1 dummy unit

1虚拟样品

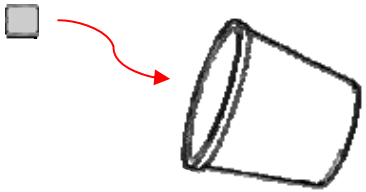
- 1 live unit

1实际产品

- 24 Hours
- 125°C +/- 5°C

- Tribo-charged 1 hour after baking

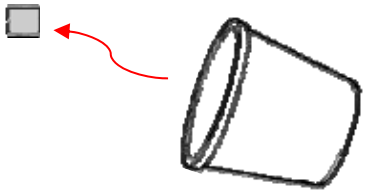
烘焙1小时后进行摩擦充电



- Put unit in Faraday's cup

把样品/产品置入法拉第杯中

Record记录 **Q_t [net]**



- The Unit were discarded from the Faraday's Cups

从法拉第杯中取出样品/产品

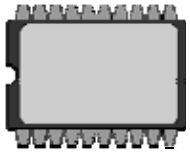
Record记录 **Q_m [mobile]**

- Find **Q_{im} ($Q_{im}=Q_t-Q_m$) [immobile]**

- Repeat experiment with Units tribo-charged 72 hours after baking

重复实验，烘焙72小时后进行摩擦充电

2. Methodology (Experiment 3 & 4)



- 88 pin FBGA 10x10 package
- 10 dummy units

10虚拟样品

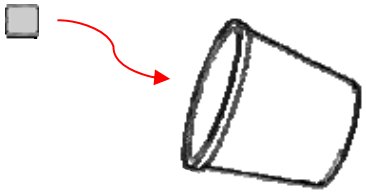
- 10 live units

10实际产品

- 24 Hours
- 125°C +/- 5°C

- Tribo-charged 1 hour after baking

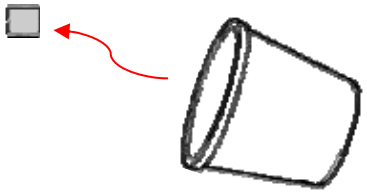
烘焙1小时后进行摩擦充电



- Slide 10 units in Faraday's cup with antistatic tube.

通过抗静电管置入10个样品/产品到法拉第杯

Record 记录 **Q_t [net]**



- The 10 units were discarded from the Faraday's Cups

从法拉第杯中取出这10 个样品/产品

- Record 记录 **Q_m [mobile]**
- Find **Q_{im} ($Q_{im}=Q_t-Q_m$) [immobile]**

- Repeat experiment with Units tribo-charged 72 hours after baking

重复实验，烘焙72小时后进行摩擦充电

I1

3. Results (Experiment 1 & 2)

1 hour after baking （烘焙1小时后）

- Average mobile charge (Absolute)

绝对**平均移**动静电

  - Dummy > Live
  - 0.18nC Vs 0.12nC

- Average immobile charge (Absolute)

绝对平均不动**静**电

  - Dummy > Live
  - 0.25nC Vs 0.09nC

No.	Qm		Qim	
	Dummy	Live	Dummy	Live
$\bar{x} + 3\sigma$	0.18	0.12	0.25	0.09
$\bar{x}$	0.07	0.04	0.18	-0.02
σ	0.04	0.03	0.02	0.02
Max	0.14	0.08	0.22	0.03
Min	0.02	-0.03	0.13	-0.06

Computation rounded to the nearest decimal point
四舍五入

Slide 8

I1 Can insert beside Q2 & Q3 (nC) as unit?

lhkoh1@e.ntu.edu.sg, 19/9/2016

3. Results (Experiment 1 & 2)

72 hours after baking （烘焙72小时后）

- Average mobile charge (Absolute)

绝对平均移动静电

  - Dummy > Live
  - 0.17nC Vs 0.15nC

- Average immobile charge (Absolute)

绝对平均不动静电

  - Dummy > Live
  - 0.19nC Vs 0.10nC

No.	Qm		Qim	
	Dummy	Live	Dummy	Live
$\bar{x} + 3\sigma$	0.17	0.15	0.19	0.10
$\bar{x}$	0.06	-0.01	0.10	-0.04
σ	0.04	0.05	0.03	0.02
Max	0.14	0.06	0.14	0.00
Min	0.01	-0.08	0.04	-0.09

Computation rounded to the nearest decimal point
四舍五入

Slide 9

I3 Can insert beside Q2 & Q3 (nC) as unit?

lhkoh1@e.ntu.edu.sg, 19/9/2016

3. Results (Experiment 3 & 4)

1 hour after baking （烘焙1小时后）

- Average mobile charge (Absolute)

绝对平均移动静电

  - Live > Dummy
  - 0.38nC Vs 0.22nC

- Average immobile charge (Absolute)

绝对平均不动静电

  - Dummy > Live
  - 0.44nC Vs 0.22nC

No.	Qm		Qim	
	Dummy	Live	Dummy	Live
$\bar{x} + 3\sigma$	0.22	0.38	0.44	0.22
$\bar{x}$	0.08	0.19	0.23	0.10
σ	0.05	0.07	0.07	0.04
Max	0.16	0.29	0.33	0.21
Min	0.01	0.08	0.10	0.05

Computation rounded to the nearest decimal point
四舍五入

3. Results (Experiment 3 & 4)

72 hours after baking （烘焙72小时后）

- Average mobile charge (Absolute)

绝对平均移动静电

  - Live > Dummy
  - 0.28nC Vs 0.22nC

- Average immobile charge (Absolute)

绝对平均不动静电

  - Dummy > Live
  - 0.34nC Vs 0.09nC

No.	Qm		Qim	
	Dummy	Live	Dummy	Live
$\bar{x} + 3\sigma$	0.22	0.28	0.34	0.09
$\bar{x}$	0.05	0.13	0.19	0.03
σ	0.06	0.05	0.05	0.02
Max	0.15	0.25	0.31	0.07
Min	-0.05	0.03	0.10	-0.01

Computation rounded to the nearest decimal point
四舍五入

4. Discussion (Experiment 1 & 2)

- Experiment 1 (Mobile charge) 实验1移动静电
  - Dummy > Live
- Experiment 2 (Mobile charge) 实验2移动静电
  - Dummy > Live

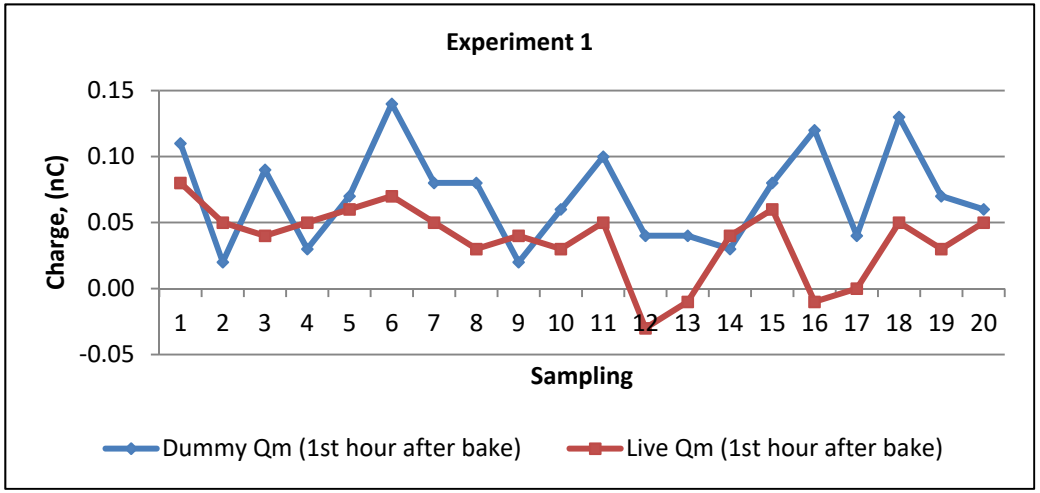


Figure 1a Qm values for Experiment 1

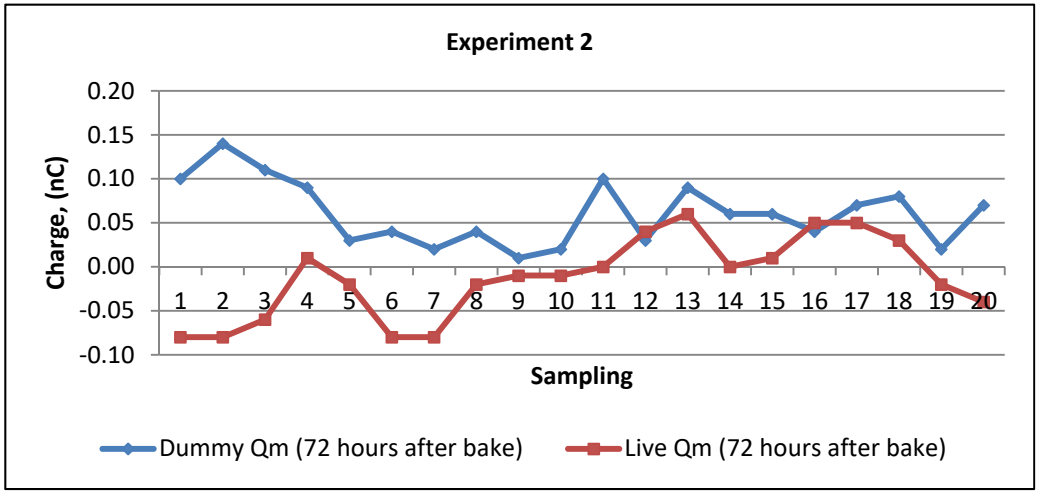


Figure 1b Qm values for Experiment 2

4. Discussion (Experiment 1 & 2)

- Experiment 1 (immobile charge) 实验1不动静电
  - Dummy > Live
- Experiment 2 (immobile charge) 实验2不动静电
  - Dummy > Live

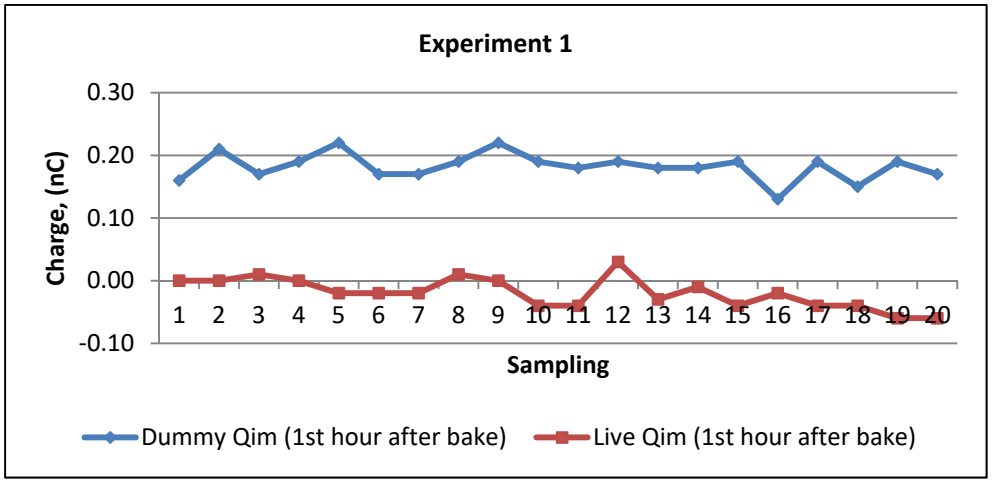


Figure 1c Qim values for Experiment 1

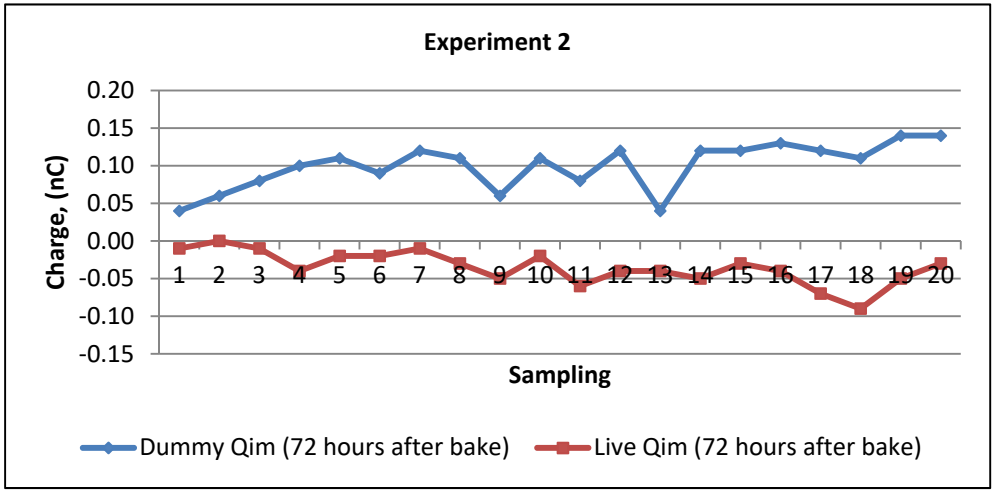


Figure 1d Qim values for Experiment 2

4. Discussion (Experiment 1 & 2)

- Mobile charge for dummy units 虚拟样品移动静电
  - After 1 hour ~ After 72 hours
- Immobile charge for dummy units虚拟样品不动静电
  - After 1 hour > After 72 hours

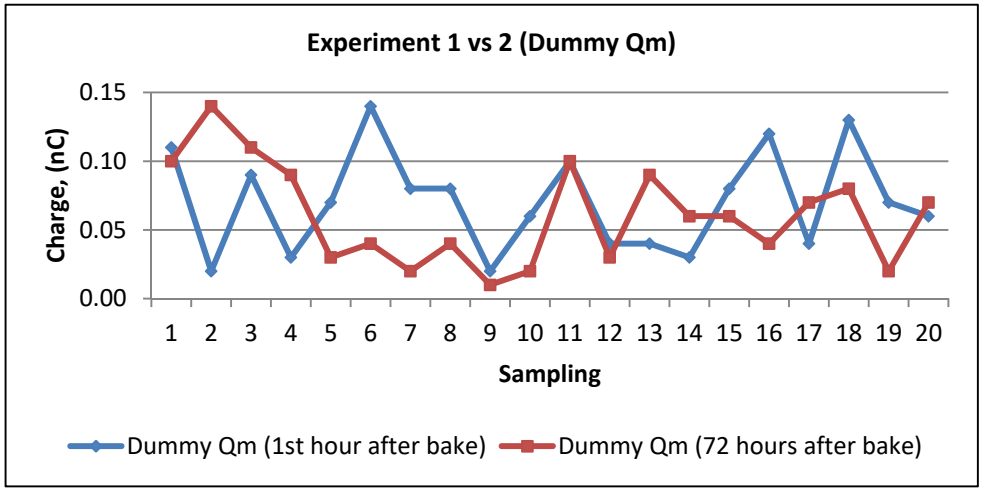


Figure 2a Qm values for dummy units

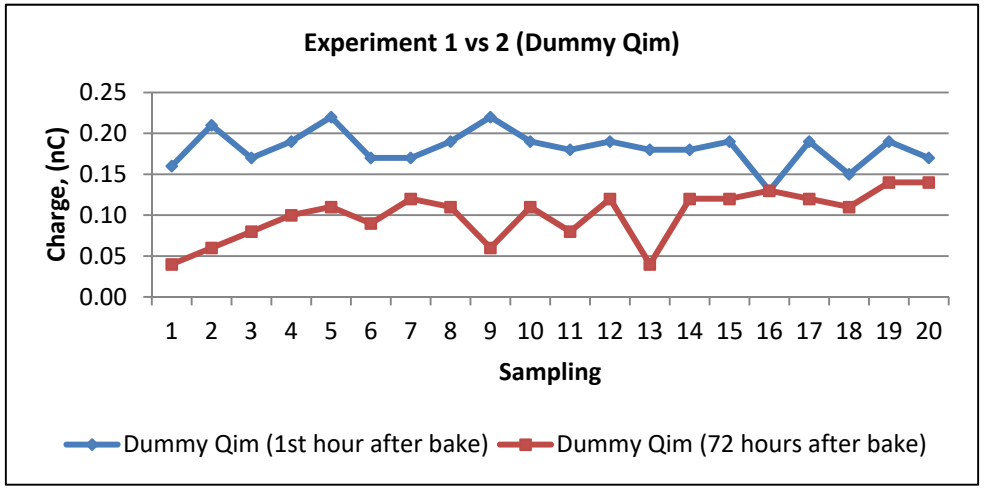


Figure 2b Qim values for dummy units

4. Discussion (Experiment 1 & 2)

- Mobile charge for live units, generally 实际产品移动静电, 大多数
  - After 1 hour > After 72 hours
- Immobile charge for live units, generally 实际产品移动静电,大多数
  - After 1 hour ~ After 72 hours

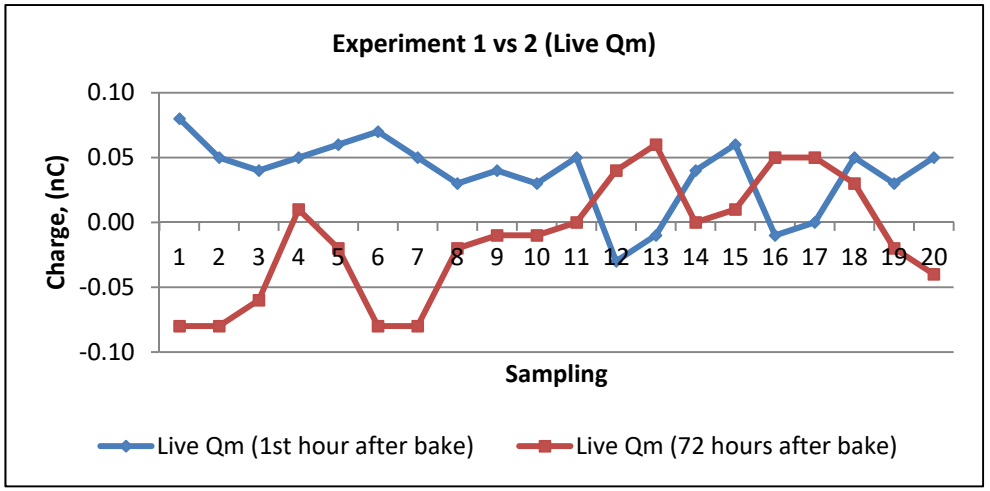


Figure 2c Qm values for live units

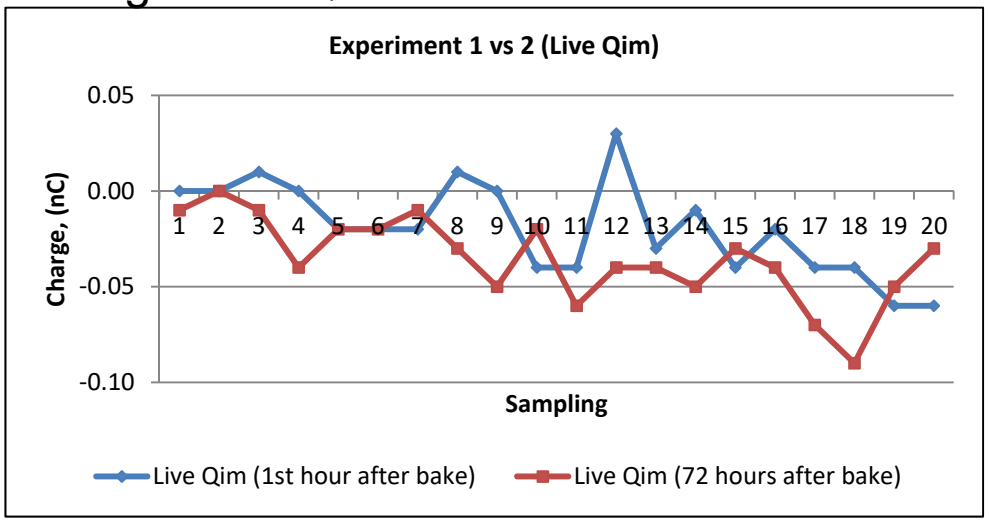


Figure 2d Qim values for live units

4. Discussion (Experiment 3 & 4)

- Experiment 3 (Mobile charge) 实验3移动静电
  - Live > Dummy
- Experiment 4 (Mobile charge) 实验4移动静电
  - Live > Dummy

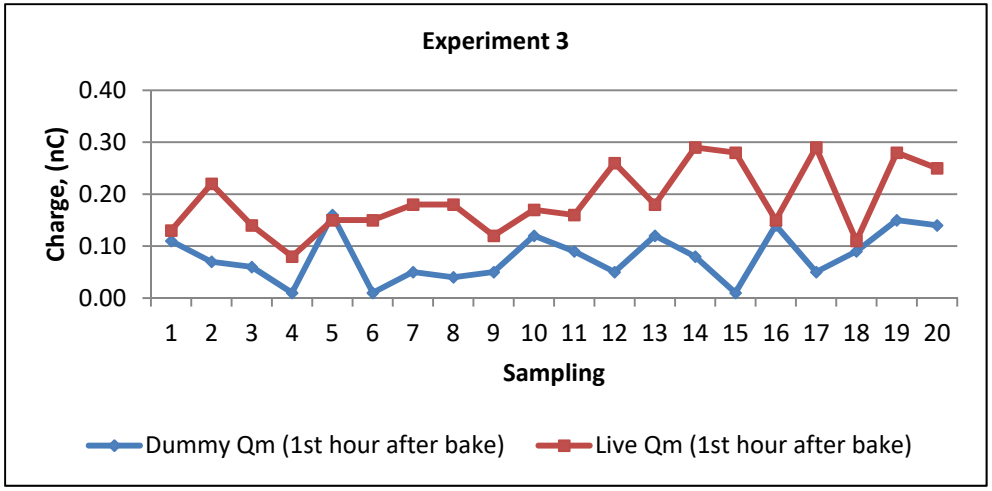


Figure 3a Qm values for Experiment 3

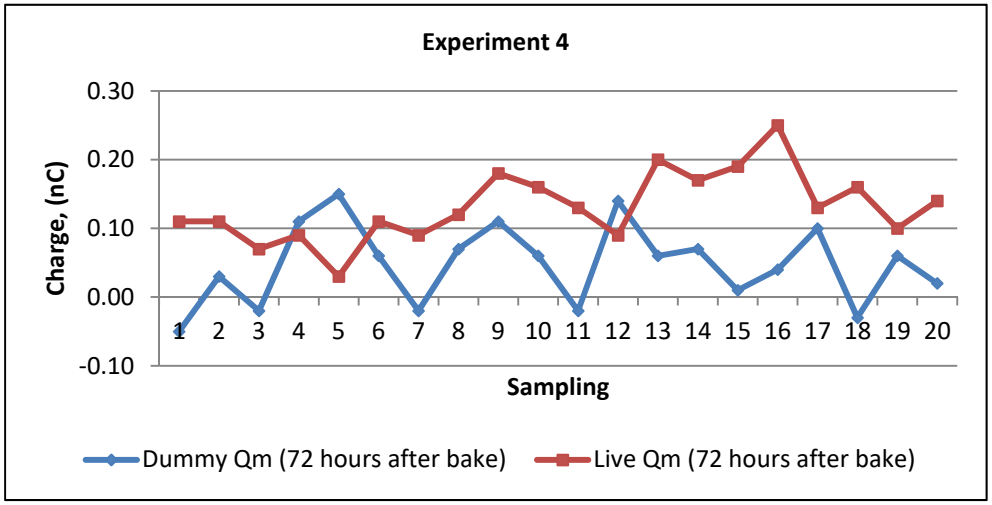


Figure 3b Qm values for Experiment 4

4. Discussion (Experiment 3 & 4)

- Experiment 3 (immobile charge) 实验3不动静电
  - Dummy > Live
- Experiment 4 (immobile charge) 实验4不动静电
  - Dummy > Live

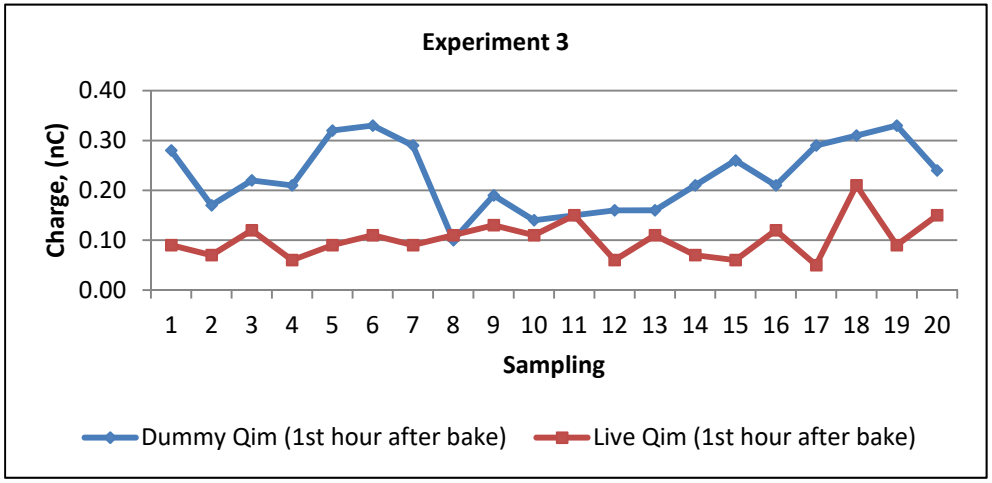


Figure 3c Qim values for Experiment 3

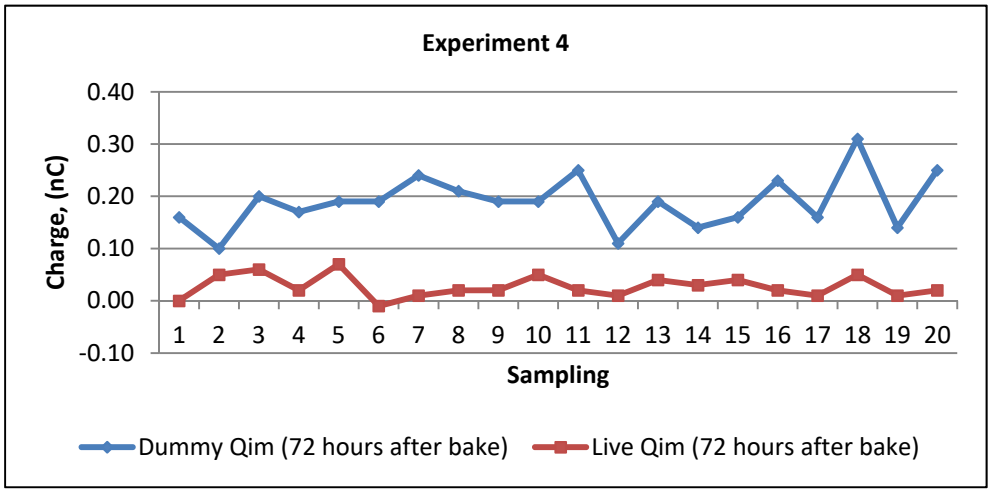


Figure 3d Qim values for Experiment 4

4. Discussion (Experiment 3 & 4)

- Mobile charge for dummy units虚拟样品移动静电
  - After 1 hour ~ After 72 hours
- Immobile charge for dummy units虚拟样品不动静电
  - After 1 hour ~ After 72 hours

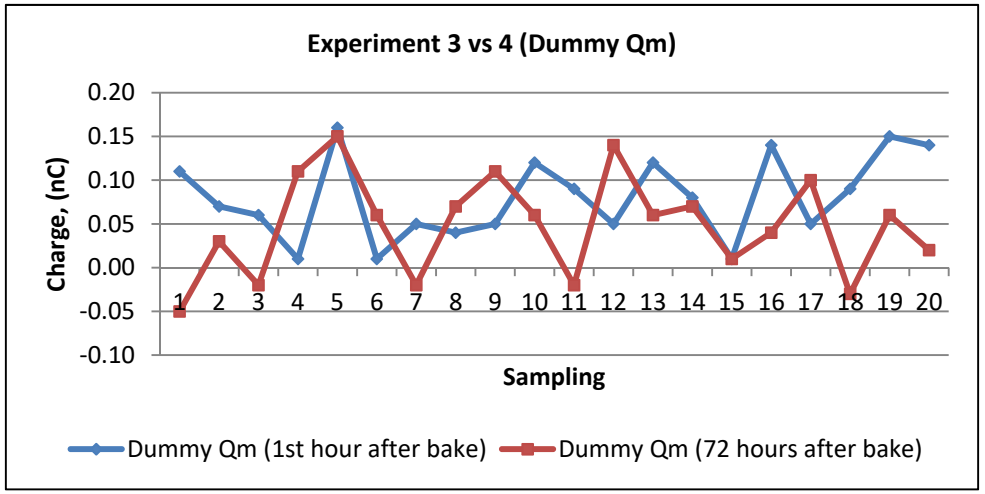


Figure 4a Qm values for dummy units

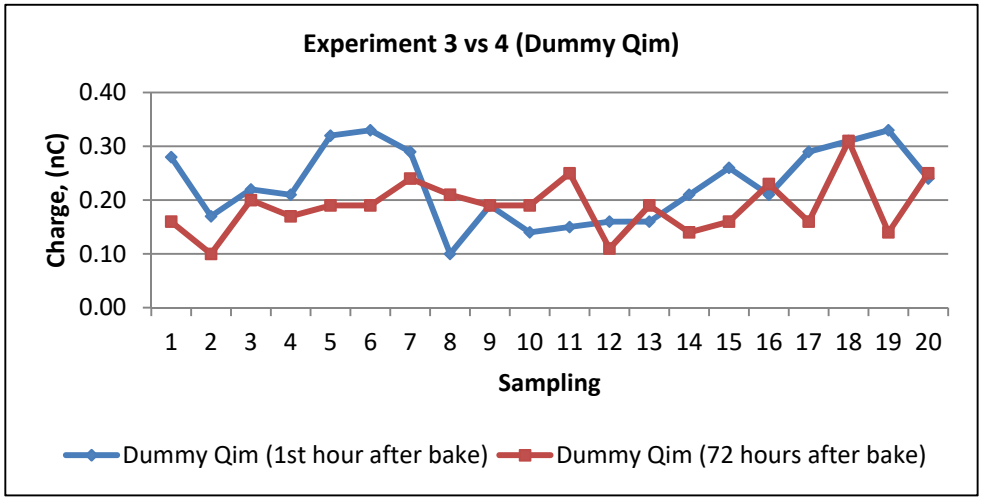


Figure 4b Qim values for dummy units

4. Discussion (Experiment 1 & 2)

- Mobile charge for live units, generally 实际产品移动静电,**大多数**
  - After 1 hour > After 72 hours
- Immobile charge for live units 实际产品**移**动静电,
  - After 1 hour > After 72 hours

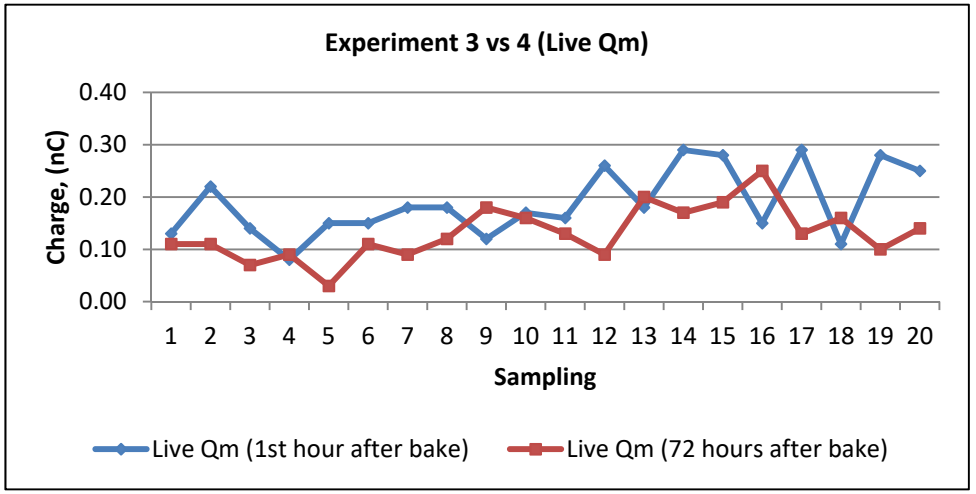


Figure 4c Qm values for live units

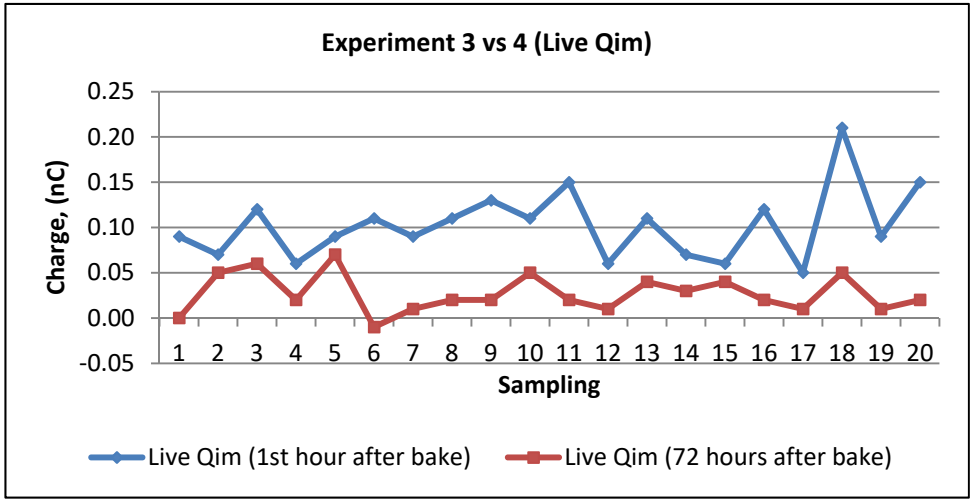


Figure 4d Qim values for live units

4. Discussion (Summary)

Summary of Dummy vs Live	84 pin FcLBGA 10x10		88 pin FBGA 10x10	
	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Higher Qm (D/L)	D	D	L	L
Higher Qim (D/L)	D	D	D	D

- Experiment 1 & 2 shows dummy has higher Qm (mobile charge), while experiment 3 & 4 shows live has higher Qm (mobile charge)

实验1和2显示虚拟样品具有较高的Qm（移动静电），而实验3和4显示实际产品有较高的Qm（移动静电）

- All 4 experiments shows dummy has higher Qim (immobile charge)

所有4个实验显示，虚拟样品具有较高的Qim（不动静电）

4. Discussion (Summary)

Summary of 1st vs 72 hours	84 pin FcLBGA 10x10		88 pin FBGA 10x10	
	Experiment 1 (1st hour)	Experiment 2 (72 hours)	Experiment 3 (1st hour)	Experiment 4 (72 hours)
Dummy Qm	Similar		Similar	
Dummy Qim	Higher	Lower	Similar	
Live Qm	Higher	Lower	Higher	Lower
Live Qim	Similar		Higher	Lower

- All 4 experiments show 1st hour after baking, live and dummy units have higher charges than 72th hours after baking.

所有4个实验显示，烘烤后1小时的样品或者产品，相对于烘焙后72小时，具有更高的静电

5. Conclusion

- Dummy units have higher mobile charge than live units in experiment 1 & 2 while vice versa in experiment 3 & 4.

实验1和2的虚拟样品比实际产品具有更高的移动静电，而在实验3和4中则相反。

- Dummy unit has generally higher immobile charge than live units.

虚拟样品通常具有比实际产品更高的不动静电

- Thus, dummy unit is not a very good representation of live units.

因此，虚拟样品不能很好代替实际产品

- It is recommended that in AHE ESD qualification, live unit shall be used to minimize the deviation of similar characteristics.

建议在AHE ESD认证中，应使用实际产品去减少认证中的偏差。

- All 4 experiments results on the 1st & 72th hours after baking are suggesting that just after baking process has higher potential in tribo-charging.

所有的4个实验结果表明 (不同的烘焙时间），产品在刚刚烘焙后具有更高摩擦充电的可能性。

6. Acknowledgement

- Special mention to Muhammad Hamizan Bin Abdul Samad, Mohamed Farhan Bin Azmi and Mohamed Ibrahim s/o Badruddin for contributing and correcting various parts of this paper with attention and care.
- Special mention to Jenny Xie De Hui for contributing in Chinese translation.

7. References

[1] E. S. D. Association, "Triboelectric Charge Accumulation Testing," E.S.D. Association, Rome, NY1995 1995.