

Microdischarge debug with CCD

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1. About microdischarge and hot electron

Microdischarge is occurred by high electric field.

edge design of electrode, bulk non-uniformity due to impurities, scratches on the silicon surface, etc.

When the electric field becomes high, electron avalanche develops.

In this situation, electron temperature becomes higher than lattice temperature.

Hot electrons

Using a cooled CCD camera, we can make images of infrared radiation from hot electrons.

2. Setup



We used, wide-angle lens, (covers $\sim \frac{1}{2}$ of the module) microscope lens, (enlarged view up to 600 μ m x 600 μ m). HPK digital CCD camera Specifications Effective area: 12.3mm × 12.3 mm Effective # of pixels: 512 (H) × 512 (V) Pixel size : 24 um × 24 um Read out noise : 12 electrons r.m.s Dark current : 3 electrons/pixel/sec @ -50degC A/D converter : 16 bit





3. IV characteristics

Sample modules : 2022017020xxxx, from mass production (xxxx = 0069, 0099, 0100, 0106)



IV characteristics

Microdischarge appeared above 400 V.

4. Procedure of microdischarge debug

[0] Choose a module with microdischarge,

[1] Take a picture in light,

[2] Take a noise image,

[3] Take a hot spot image applying HV up to 550 V,

[4] Subtract noise from hot spot image ([3] - [2]),

[5] Superimpose [4] on the [1].

Exposure time { 10 mins (wide-angle) 1 to 3 mins (microscope)

5. Results ID = 100 (the biggest current @ 550 V) Hot spot was observed on the sensor 4 (backside of the module). Enlarged



(X 2 maginification)

The cause of hot spot is investigated by the visual inspection.

5. Results (Cont'd) Visual inspection





The cause of hot spot was a shave off a bonding wire.

Because of the contact, decay time of microdischarge is longer.

It was in contact with the surface of detector.

5. Results (about the regular spots on the ASICs)

To identify the spots, we set the HV power OFF, the power to ASICs from SCTLV OFF and VME power ON.

We still found the luminous spots. The enlarged view of the luminous spot is ...



x10 magnification

According to chip designer: "The luminous spot is due to a diode for the prevention of ESD.

When the difference of potential between Vdd and Reset B is larger than 0.6 V, the diode starts working."

We measured the ResetB with a tester.

ResetB = 1.5 V @ Vdd off

5. Results (Cont'd)

To confirm the function of ESD diode, we took pictures with Vdd = 4.0 V.

ResetB = 4.5 V @ Vdd on (design value : 4.0 V)



Previous spots disappeared. Other luminous spots were due to heat in the ASICs.

Working correctly !!



Wide-angle view(upper), x20 magnification picture (lower)

6. Summary

We have started to locate microdischarge points in series modules with the CCD camera.

We examined 4 modules, their causes of microdischarge are;

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0100 : shave off bonding wire,

0069 :

0099 :

0106 :
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Besides sensor microdischarge, the luminous spot of the diode to the ResetB were observed, too.

