Massachusetts Institute of Technology

Center for Space Research
Cambridge, MA 02139
Room 37-521
mwb@space.mit.edu

February 17, 2003

To: XIS Team
From: Mark Bautz
Subject: XIS CCD Edge-glow status

Summary and Current Status

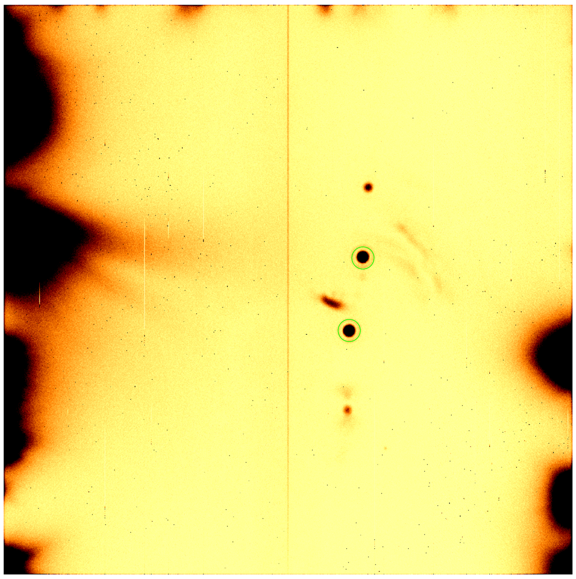
This memo summarizes the intermittent "edge-glow" phenomenon observed recently on 2 XIS CCDs (L1W4C6 and L1W4C7) and one ACIS CCD (w168c4r.) At this writing none of these devices exhibits edge glow under nominal operating biases. While we believe we understand the mechanism responsible for the glow, we do not yet understand why the glow is intermittent. Following a brief description of the phenomenon and the physical mechanism believed responsible for the glow, some preliminary conclusions are suggested. A detailed chronology of glow comings and goings is appended.

Edge glow Phenomenology

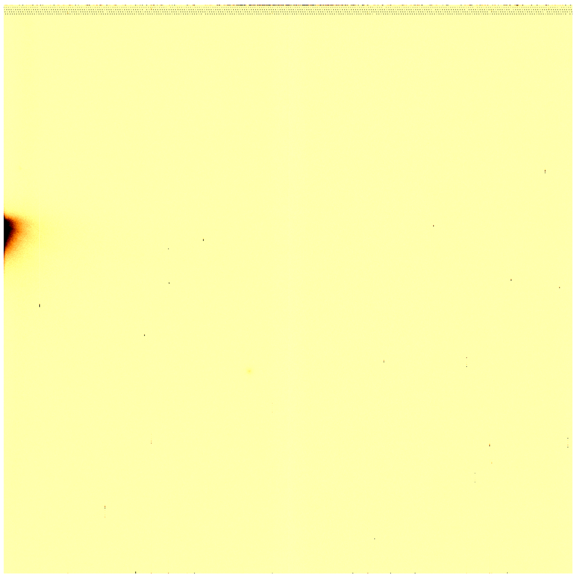
An intermittent "edge glow" has been observed on two XIS flight candidate CCDs. Edge glow is seen as bright "blobs" of injected signal protruding from the edges of the detector (see Figure 1.) We believe edge-glow is caused by high-field regions associated with micro-cracks that are both i) near the edge of the detector and ii) near the p-n junction associated with the CCD back junction. The microcracks are produced when the wafer is sawn into individual detectors. The associated high-field regions lead to avanlanche multiplication of diode leakage current in the back junction. Recombination of (some of) the electrons and holes associated with this current leads to emission of infrared photons which travel long distances (mm) in the silicon before being absorbed. The observed "glow" is thus due to photo-excited electrons produced by the absorbtion of the IR radiation.

We did not see this problem on any XIS CCDs until early in January when one flight candidate (L1W4C6 = w1.4c6) suddenly developed the problem after several weeks of calibration. The glow signal disappeared and reappeared at least twice. Some weeks later, a second flight candidate detector (L1W4C7 = w1.4c7) also developed the problem. An ACIS quantum efficiency reference detector (w168c4r) mounted in the chamber with w1.4c7 also developed the edge glow at about the same time. As of this writing, the edge glow has disappeared from all three of these detectors. More details are given in the next section.

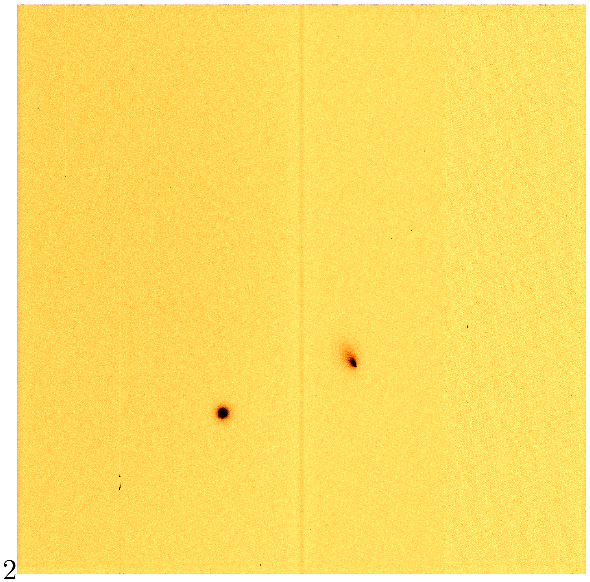
Edge glow was seen on the ASCA detectors, but one important difference between ASCA and XIS-2 edge glow is that on ASCA the edge glow did not appear to be intermittent. We suspect (but have not demonstrated) that the XIS-2 glow is intermittent because of some kind of chemical instability occuring on the sawn edges. In fact, for ASCA we had to use a special procedure to etch the sawn edges for each detector before packaging in order to eliminate the edge glow. This process was quite effective for ASCA, though it did reduce the net yield. Neither ACIS nor XIS-1 devices ever showed edge glow at the back-junction bias (12-15V) that we used for those devices



2 January 2003, when edge glow was first discovered, while cooling the detector in the "butthead" chamber. The two spots surrounded by green circles are from alignment lights projected onto the CCD. The detector temperature is unknown, but is significantly warmer than -90C. Some dark current spikes are evident.



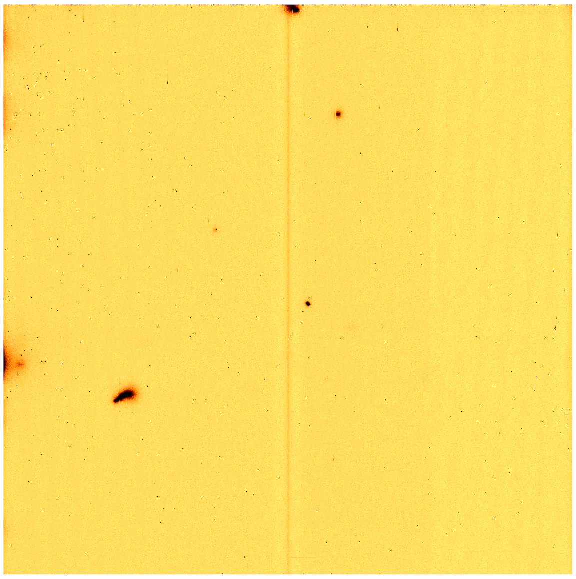
7 January 2003 in the IFM chamber. The glow has changed considerably. The dark features at the top are intentionally injected via the charge injection register.



10 February 2003 in the butthead chamber. The glow has disappeared.

Figure 1: Examples of edge glow in XIS detector L1W4C6 = w1.4c6. All images are shown at the same color scale, with black indicating high signal ($\sim 500e^{-}$) and yellow indicating low signal. Each is a single 8-second exposure, and cosmic ray tracks are evident. Quadrant A is to the left and row 1 is at the bottom.

28 January 2003, just after edge glow was detected in w1.4c7, following a roughing pump failure in the "butthead" chamber. The glow region is much smaller than seen on w1.4c6.



14 February 2003 in the butthead chamber. The glow has vanished.

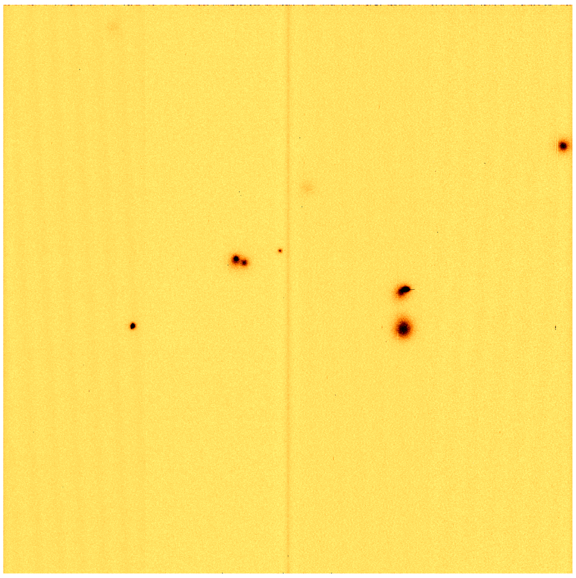


Figure 2: Examples of edge glow in XIS detector L1W4C7 = w1.4c7. All images are shown at the same color scale, with black indicating high signal ($\sim 500e^-$) and yellow indicating low signal. Each is a single 8-second exposure, and cosmic ray tracks are evident. Quadrant A is to the left and row 1 is at the bottom.

during calibration of CCDs for those instruments, and neither ACIS nor XIS1 CCDs had etched edges.

Summary and inferences about edge glow

- Three ccds have shown glow to date: w1.4c6 (=L1W4C6), w1.4c7 (=L1W4C7) and w168c2r. The last of these is an ACIS detector.
- No ccds show glow (at Vbj=12V) at this writing (17 Feb 03).
- The glow responds to changes in back junction voltage (Vbj) as expected, so glow is, in fact, associated with the back junction.
- At Vbj= +5V glow disappears (on chips where this value of Vbj was tested.)
- In all cases glow was first noticed in butthead chamber.
- It is likely that the first appearance of glow was preceded in each case by rapid pressure change in the butthead chamber.
- In all cases the disappearance of the glow occurred only after exposure of the detector to air.

XIS CCD Edge Glow Chronology

Date	Event
2 Jan	**w1.4c6 glows in butthead;** w168c4r does not. Glow noticed just after Christmas/New Year's break. Chamber was "valved off" before Christmas but not vented to 1 atm. After Chritmas was pumped down from an unknown (but probably subatmospheric) pressure) Glow persists through warmup, power cycle.
6 Jan	W1.4c6 transferred to IFM; shows no glow. Run overnight at room temperature in vacuum in IFM.
7 Jan	Some w.1.4c6 glow in IFM.
9 Jan	w1.4c6 sent back to LL; passes Keithley; no problems seen in visual inspection there.
10Jan	w1.4c6, back at MIT, shows no glow in IFM Ran for 1 week in IFM, showed no glow.
27 Jan	**w1.4c7 glows in butthead** following a roughing pump failure over the weekend.
28 Jan	w1.4c7 glow persists in butthead through power cycle, warm up to room temperature. Glow disappears at backjunction voltage (Vbj) =+5V; is worse at Vbj >12 V.
29 Jan	w1.4c7 transferred from butthead to IFM, and does not glow in IFM.
29 Jan	**ACIS detector w168c2r shows glow in butthead.**This detector has been in butthead as reference since October 2002 (or earlier). This is first operation of w168c2r since w1.4c7 was seen to glow on 27th Jan. Both detectors were in butthead together at time of pump failure on 25-27 Jan. Temperature cycle (to room temp) in butthead did not change glow of w168c2r. Toggle of Vbj to 80V made glow worse.
$\sim$30 Jan	w168c2r transferred to IFM, still shows some glow."Baked" to +60C overnight in vacuum, then briefly exposed to air. Then pumped down, cooled in IFM; glow much reduced but not gone. Then sat 24 hours in air, repumped, cooled in IFM. No glow is observed there.
7 Feb	Butthead chamber wiped down. No visible residue; some particulates on o-ring seal. Both w1.4c6 and w168c2r re-installed in butthead. Sit in vacuum over weekend at room temperature.
10-13 Feb	Both w1.4c6 and w168c2r operated in butthead; neither glows.
14 Feb	Both w1.4c7 and w168c2r operated in butthead; neither glows.