Technical Note 104

Baking the Loral CCD and Cryostat to Remove Water Vapour Contamination.

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1. Introduction.

The Loral CCDs can become subject to the effects of water vapour contamination which manifests itself as a dramatic decrease in Ultra-violet response when cold. This problem usually results from contamination whilst the dewar is being brought up to room temperature and where the chip may have become colder than the surrounding environment. The problems which this caused during the time the device was being tested at RGO led to the solution which is described in this document. On 2 separate occasions at the RGO the baking process was found to be successful in removing the water vapour contamination of the chip surface, resulting in complete restoration of the ultra-violet (UV) quantum efficiency (QE) when cold.

The process of pumping the cryostat for a long period of time (a few days) with the chip mounted inside did not prove to be a viable alternative. Water molecules, which it was assumed had become fairly tightly bound to the chip surface, could only be removed by the application of heat. This resulted in a repeatable performance from the chip during the ensuing flooding process, providing the UV response expected from these devices (see Technical Note #103).

2. Baking Process - Equipment.

To perform the bake-out process, the chip will have to be brought up to room temperature. The cryostat should be emptied of liquid Nitrogen (LN_2) the day before baking is to take place to allow the chip and the internal components of the cryostat to reach room temperature in a controlled fashion. The cryostat temperature **should not** be raised in an artificial manner as this *may* introduce water vapour onto the surface of the chip if this becomes cooler than the rest of the inside of the cryostat.

The equipment required to bake out the cryostat and CCD are -

- the IsoPad, 7.5m heater tape,
- A timer or other control device for the heater tape,
- a digital thermometer to measure the external temperature of the cryostat,
- a temperature connector for the cryostat to monitor the chip temperature using the resistance of the Platinum resistance thermometer (PLT)
- A DC supply to raise the chip temperature to 90°C (for the Loral CCDs) via the block heater resistors.

The details follow relating to baking the CCD alone or the CCD and Cryostat. **The Cryostat should never be baked alone, the chip MUST always be at least as hot as any other component. If this advice is not followed there is a possibility that contamination from within the warm interior of the cryostat may adhere to the cooler surface of the chip.**

3. Baking Process - CCD Only.

Heating the chip can be done simply and safely by using a DC supply of 30V (with a current drive capable of around 300mA), similar to that used in the process of cleaning the getter in the cryostat when

this is required. The temperature of the chip and block should be monitored at all times and **not allowed to rise above 90°C**. This is to ensure that materials which may be present in the chip package do not undergo any catastrophic changes; for example, the melting point of Indium, used to provide electrical connections from the front to the rear of the Silicon, melts at 156°C.

The Platinum Resistance thermometer has a **0.385 Ω/C** temperature characteristic, and has a nominal resistance of 100Ω at 0°C . This means the resistance should not go above 135Ω when the baking is taking place. Monitor the block platinum resistance thermometer during all of the procedure for baking. A D.V.M. between pins E-F on the temperature control connector should be used. The DC supply should be connected to pins A-B, the connections to the 100Ω internal heater resistors on the rear of the cold block. The process can be crudely controlled by manually manipulating the DC supply between about 15 and 25 volts. The DC supply from the CCD controller is not suitable for this operation. The process of controlling the current to the block resistors should be done manually to ensure the chip does not reach too high a temperature.

The turbo-pump should be operated during this time. After about half an hour the pump should be turned off and the cryostat allowed to back fill through the getter at the rear of the pump (this will permit warm dry air to absorb any water vapour in the cryostat volume and was recommended by Oxford Instruments during initial inquiries about this process). Use the Balzers diaphragm turbo pump if possible for this operation. Leave the cryostat about an hour with the DC supply to the heaters turned off. After this the process can be repeated again, power up the DC supply to the chip block and commence pumping again. Again ensure the chip temperature doesn't go beyond about 90°C .

Once this process is finished, the chip block should be allowed to return to normal temperature (about 108Ω on the DVM) keeping the cryostat on the pump and evacuated all the time. Once the chip is at room temperature, the cryostat should be back-filled through the pump as earlier, just switch off the Turbo and the pump will spin down. After this, the valve on the pump getter will be opened automatically and air allowed to pass into the cryostat.

Once the cryostat is full of dry air the chip can be re-flooded with the short-wavelength UV source provided. NOTE:- The flooding process has to be performed in the presence of **oxygen,** so its no use back-filling with dry nitrogen, the flooding will not work!

4. Baking Process - CCD and Cryostat.

As stated above if the cryostat itself needs to be baked (**in addition to heating up the ccd as described above)** then this can be fairly easily done using the AC heater tape provided. This has a heat capacity of around 5W/sq. inch and can easily get the body of the cryostat up to around 120°C. Attempt to achieve a temperature of around 90°C, similar to the CCD. The tape should be coiled around the cryostat leaving a 1cm gap between each coil. Do NOT overlap the tape or cross layers over - the tape will get too hot and may burn. The free end can be wrapped around the vacuum port to secure it and then coiled down the body of the cryostat to the feedthrough connectors. The remaining tape may trail on the floor away from anything which it may adversely affect. The temperature probe can be inserted between the cryostat and one loop of the coil. In Cambridge this was achieved using an AC timer to switch the tape on and off every 15 minutes for the duration of the bake whilst the chip and block were also being heated via the DC supply, as described above.

The tape should get the whole of the cryostat body up to around 90°C - it is very hot and will take a while to cool down properly - e.g. over-night. During the cool-down process the Turbo pump should be operating all the time to remove any contamination freed by the input of heat. Remember to switch off the DC supply to the chip block when this process is finished or the temperature of the chip block and CCD will rise to 150°C or more and may destroy components within the chip package rendering the CCD inoperable.

The Cryostat internal getter may also be powered up during this process this will ensure the LN_2 can and getter are also purged of any foreign contaminant.

Points to note before undertaking any baking are:-

The Loral response when operating correctly, at room temperature and when cold is, typically,

- 70% in the UV (350nm),
- 90% at the peak (600nm),
- 55% in the red (900nm),

Further,

- any water vapour which may have formed within the cryostat during a warm-up operation, will cause a loss of UV response and the cryostat and chip should be baked out,
- If there is no apparent change in the QE from the figures given above then there is no point in baking out the cryostat.

To conclude this section, there follows a simple recipe for baking the Loral CCD and cryostat-

1. Allow the chip to naturally warm up to room temperature,
2. When at ambient temperature, connect the cryostat to the turbo pump and evacuate the hose to the cryostat,
3. When the line is at good vacuum, 10^{-4} mbar, open the cryostat valve to the pump,
4. wait a few minutes to pump the whole system down a little further,
5. Switch off the pump. This will purge the cryostat through the pump, with dry air,
6. Wrap the heater tape around the cryostat body and connect to the mains,
7. set up a DC supply for the heater resistors on the back of the chip block,
8. power up the heaters, switch on the turbo pump and allow the cryostat and chip to get to 90°C, this may take 30 minutes or so,
9. Allow the cryostat to remain at this temperature for 30 minutes, turn off the power to the heaters and switch off the turbo pump - allowing the cryostat to back-fill through the pump,
10. Leave the cryostat full of dry, warm air for about an hour,
11. Repeat operations 8, 9,10 again.
12. Pump the cryostat and allow it to return to ambient temperature - this may take more than 12 hours,
13. Once at ambient temperature, for the Loral CCDs, the detector should be UV sensitised, pumped and cooled.

5. Concluding Remarks

The Loral #1 Cryostat and the CCD have both been baked well to remove any water vapour contamination.. Unless there has been a SERIOUS ingress of water vapour, the cryostat does not have to be re-baked. This makes matters much easier as the chip itself can be processed, i.e. baked with some care, on its own. This, in both previous cases, was found to be the root cause of changes in response with temperature. Baking the cryostat alone, with no chip installed, did NOT solve this problem. If however the cryostat has become contaminated then this will have to be baked in addition to the chip following the guidelines described above. Details of the flooding process for these devices can be found in-

RGO Technical Note #103, "Response Enhancement for the Loral CCDs using Ultra-Violet Flooding". July 1996, A.P.Oates .