Simulation of the Charge Transfer Inefficiency of Column-Parallel CCDs

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On behalf of the Linear Collider Flavour Identification (LCFI) Collaboration

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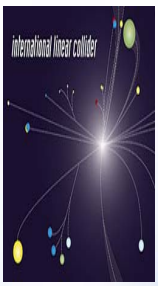


What is the International Linear Collider?

The International Linear Collider (ILC) is proposed as the next generation particle physics facility after the LHC. It will consist of two head-to-head linear accelerators colliding electrons and positrons at energies up to 500 GeV, upgradable to 1 TeV. It will enable precision measurements at the energy scales of the LHC and beyond.

Column-Parallel CCD (CPCCD)

CPCCD is one of the technologies under considerations for the Vertex detector a the ILC. CPCCDs inherit their basic operation from classic CCDs, but gains are made in the speed and radiation hardness by the parallel readout.

Advantages

- High spatial resolution
- 100% fill factor
- Large sensitive area

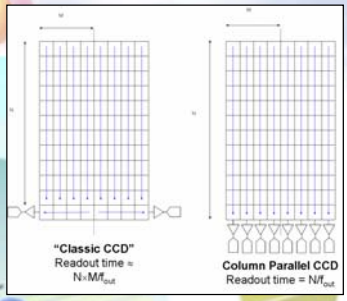
CPCCD vs. CCD

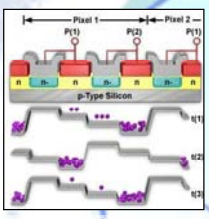
+ Significantly higher readout speed;
+ Improved radiation hardness;
- Higher power dissipation;
- Increased complexity.

What is the *Linear Collider Flavour Identification* Collaboration?

The *Linear Collider Flavour Identification* Collaboration is developing the sensors, electronic systems and mechanical support structures necessary for the construction of a high performance vertex detector at the ILC. It will investigate the contribution that a vertex detector can make to the physics accessible at the ILC.

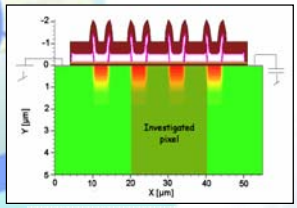
First prototype CPC manufactured by e2V





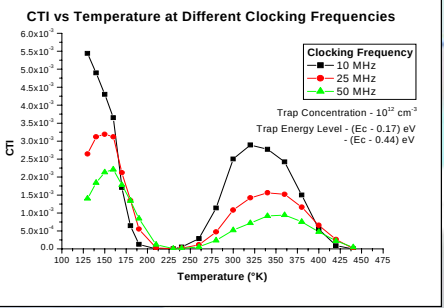
Charge trapping mechanism

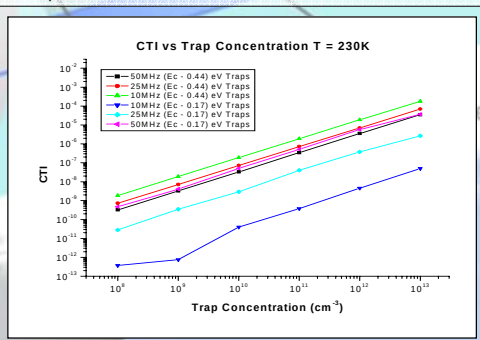
Charge Transfer Inefficiency (CTI) is the limiting factor for the radiation hardness of CCD technology. Charge may have to travel several centimetres from the place it originated to the output and there is high probability of encountering bulk defects (radiation damage) caused by high energy particles. The effects of charge trapping could be reduced by device design and by careful choice of the operating temperature and timing.

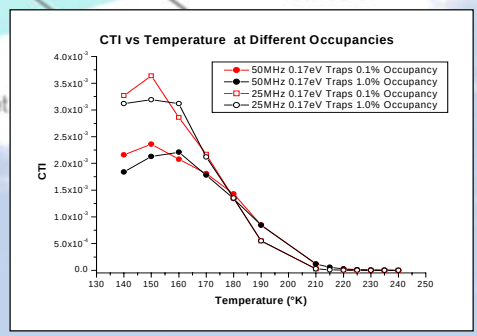


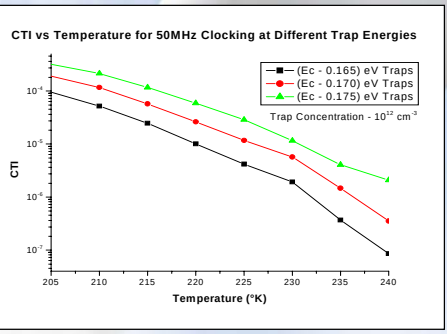
CPCCD model used for simulations

Simulations have been performed with ISE-TCAD package (v. 7.5) using the DESSIS program (**DE**vice **S**imulation for **S**mart **I**ntegrated **S**ystems).
Due to complex simulation process and limited CPU resources a simplified 2D model, containing one pixel, was used.









Estimated fluence at innermost layer of the vertex detector at the ILC:
10 MeV electrons – 0.5×10^{12} e/cm^2/year;
1 MeV neutrons – 1×10^{10} n/cm^2/year;
gives the trap densities ~10^{10} -10^{11} after one year of operation.

Results:

- Optimal operating temperature, where the effects of the trapping are at a minimum, is found to be ~230 K;
- CTI is found to depend linearly upon the trap concentration and energy level with temperature;
- Simulations indicate that the device will be able to cope with the levels of occupancy expected at the ILC in the low temperature region.

ilc international linear collider

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