The Invention and Early History of the CCD

Dr. George E. Smith
To be Covered

Bell Labs Background

CCD Invention

Device Basics

Early Devices

Applications
Magnetic Bubbles
Picturephone
MOS Capacitor
MOS Energy Diagram
Two MOS Capacitors
Three Phase CCD

\[ \phi_3, \phi_2, \phi_1 \]

\[ V_a, V_r, V_r, V_a, V_r, V_r \]

(a) \( t = 0 \)

(b) \( t = \frac{1}{3} t_c \)

(c) \( t = \frac{2}{3} t_c \)

(d) \( t = t_c \)

\[ V_p > V_a > V_r \]
First CCD
First Functional Device
MOS Energy Diagram
Buried Channel CCD
Area CCD
First Self Contained Camera
Linear CCD

1500-element gated dual-linear 4-phase charge coupled image sensor
Meet the new Omega.
If you think you can't afford an Olds, think again.

A smaller Olds at a lower price. Omega is a whole new kind of Olds—a compact. But one with Olds big-car thinking built into three interesting variations: 2-door coupe, 3-door hatchback and 4-door sedan. All of them offer a lot of Olds for the money.

Omegas are not your basic little car. It's nearly 500 pounds more car than some smaller compacts. The wheelbase is longer—111 inches. And you can feel this extra size and power working for you on the road. It's solid and steady. Roomy, comfortable. Agile and maneuverable.

You get what you bargained for. Omega gives you nice things you may have to pay extra for in other compacts. A deluxe interior with new "weel-back" vinyl trim. Full carpeting. Chrome trim around the windows and wheel openings. And 250 cubic inches of engine. There are also things some compacts don't offer at any price! A glove compartment with a door and a lock. Rear windows that roll down. And generous trunk space.

Add some neat ideas of your own. You can order a vinyl roof for looks. Our famous Rocket 350 V8 for a sporty, high-back bucket seats and a console for the coupe and hatchback. Even a special tent that converts the hatchback into a camper.

It feels like a bigger car. Get into an Omega and notice the comfort. The way you sit up, how right the steering wheel position seems. How easily the car responds. Sure, you can get a lesser compact for less money—but then it wouldn't be an Olds Omega. Oldsmobile. Always a step ahead.

'73 Oldsmobile Omega.
Aerial Photo

LINEAR IMAGE SENSORS
APPLICATION: AERIAL
RECONNAISSANCE

CCD121
1728 x 1 SENSOR IN

FAIRCHILD MINI-CAMERA

TAKEN AT:
2000 ft. ALTITUDE
150 KNOTS OVER
SOUTHERN LONG ISLAND

PHOTO REPRODUCED FROM
STORED DATA BY LASER
RECORDING PROCESS
Current Applications

Digital Cameras
TV Cameras
Scanners
Medical devices
Fax machines
Bar Code Readers
Satellite Surveillance
Earthly Surveillance
Astronomy
90% Quantum Efficiency (Film is 5%)

Long integration times (at 160° K) 20 electrons/hr/pixel)

Large dynamic range $10^5$ electrons/pixel

Repeatability eliminates systematic errors
Astronomical Camera
More Before & After
Summary

CCDs born in the Si-SiO₂ Revolution

1st Practical Solid State Imaging Device

Widespread Applications