

Applications of Lepselter Science and Technology

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and Ravi Ravindra

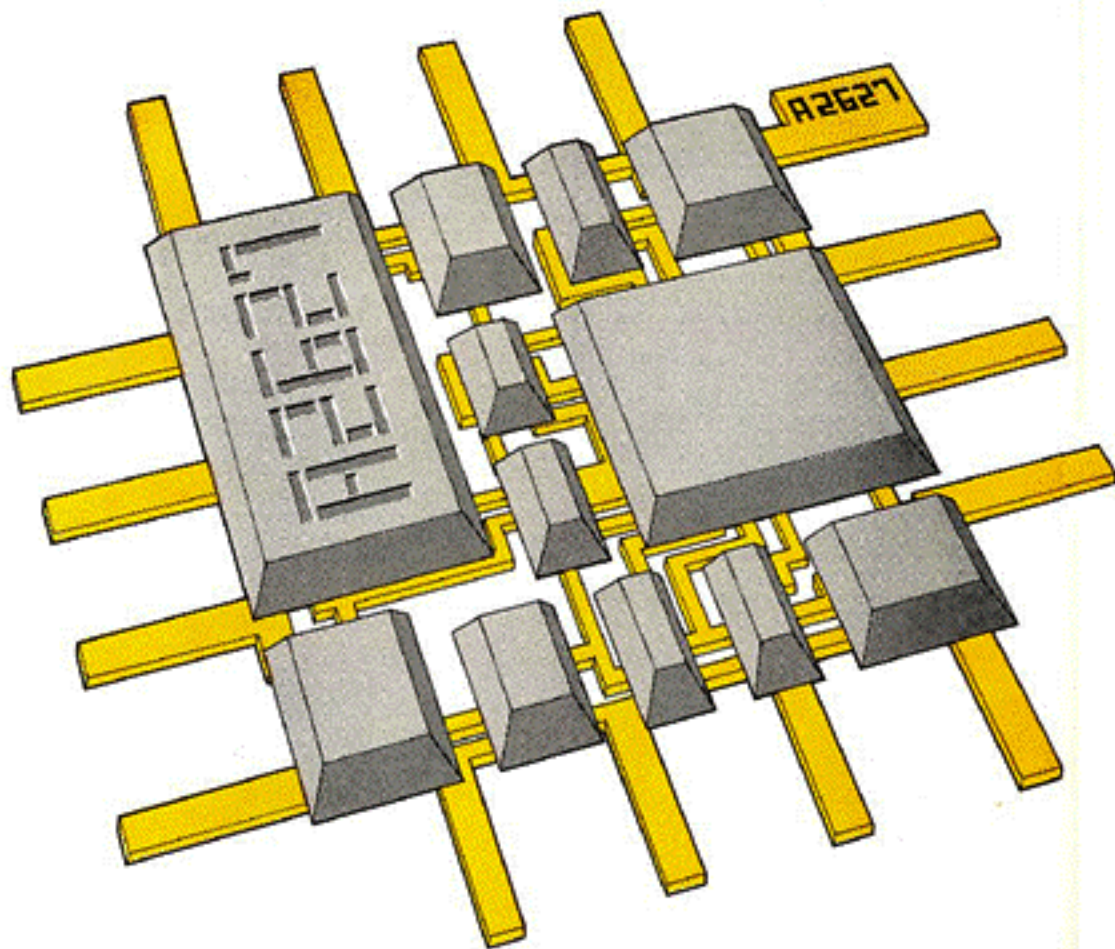
Brainstorming: 2002 – 2009

<http://web.njit.edu/~fiory>

17 November 2011

Lepseiter invented MEMS

in part to develop
beam lead device packaging
and **air-bridge** interconnect structures.



Beam-lead, sealed
junction circuits fabricated
with air isolation

Plasma reactive-ion etching
Ti-Pt-Au Metallurgy
 Si_3N_4 Passivation

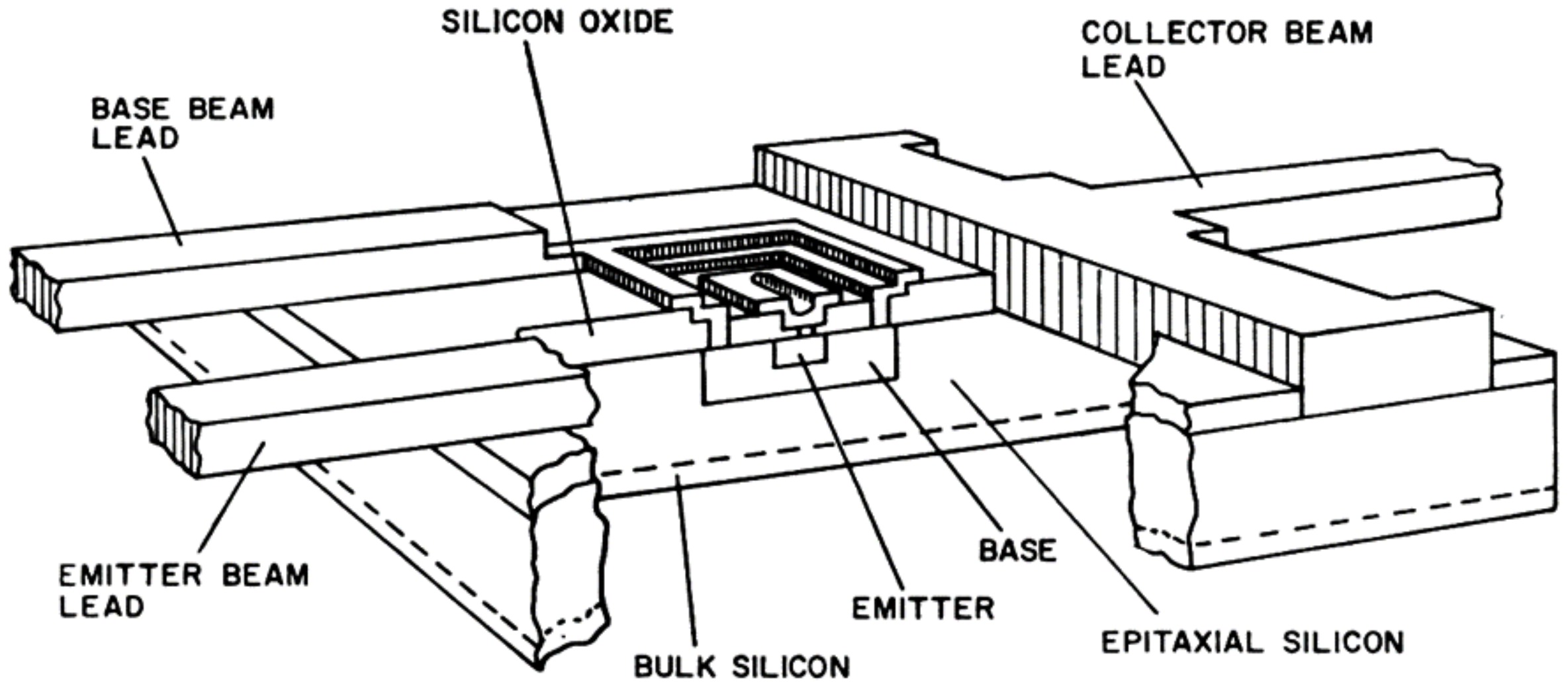
1 FIT (1 failure in 10^9 device hours)

A Few of the Technology Innovations

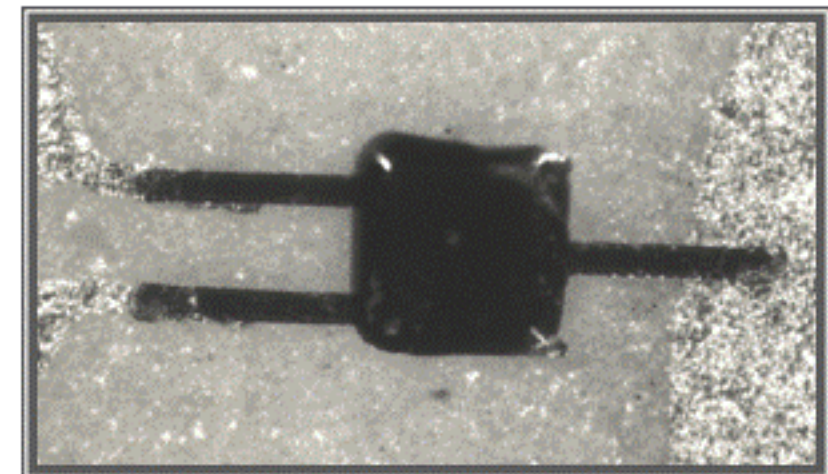
Microelectronics • Plasma Displays
Electron-Beams • Infrared

MEMS: Microbridges and Beam Leads
Plasma Etching
E-Beam Lithography
MEMS Oscillators and Bolometers
Flat Plasma Display Panels
Magnetic Self Assembly
Silicide Junctions / Photoreceivers

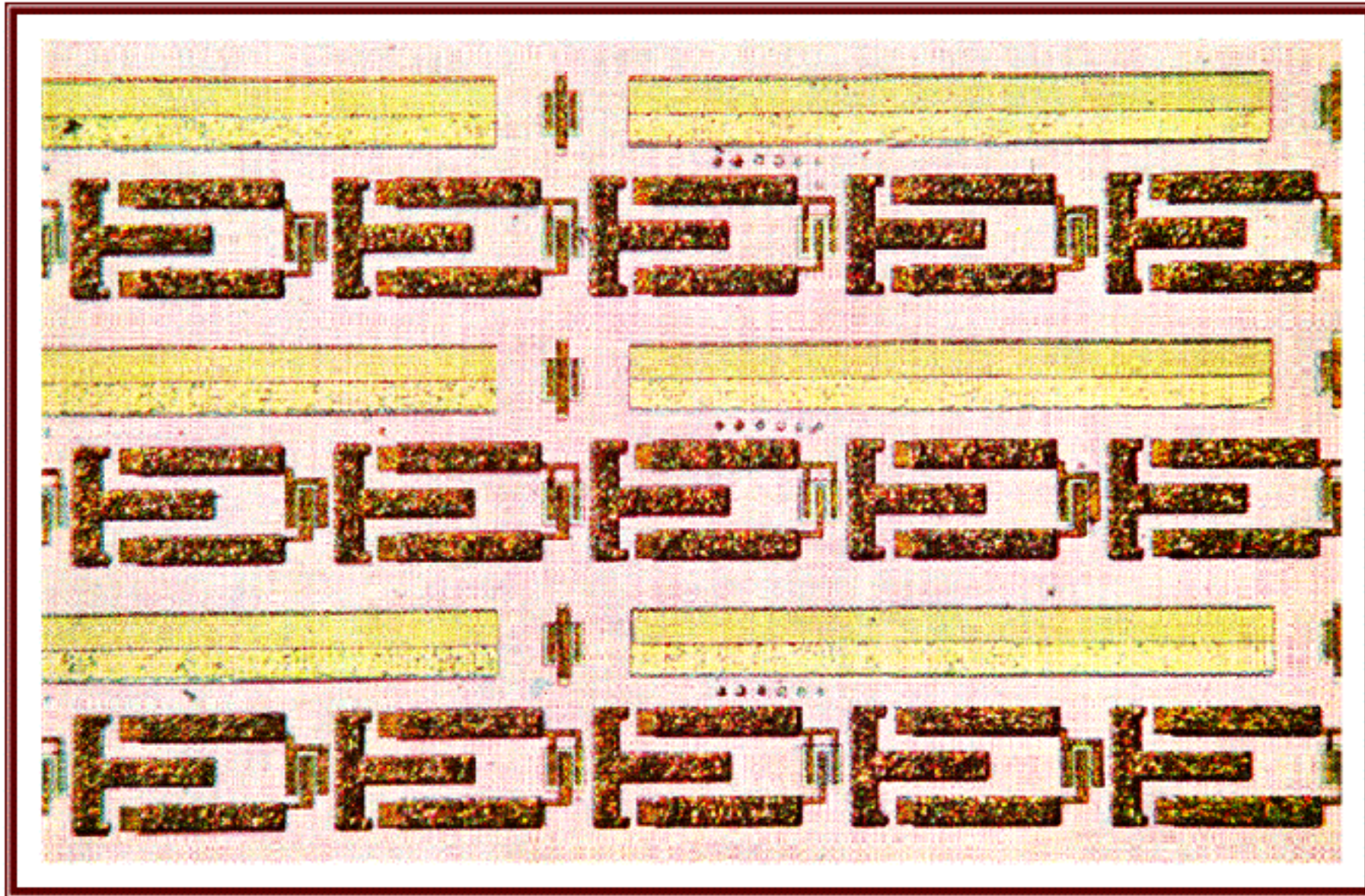
Beam-Lead Technology



Cut-away cross sectional view of a bipolar transistor fabricated in a silicon wafer using beam-lead technology

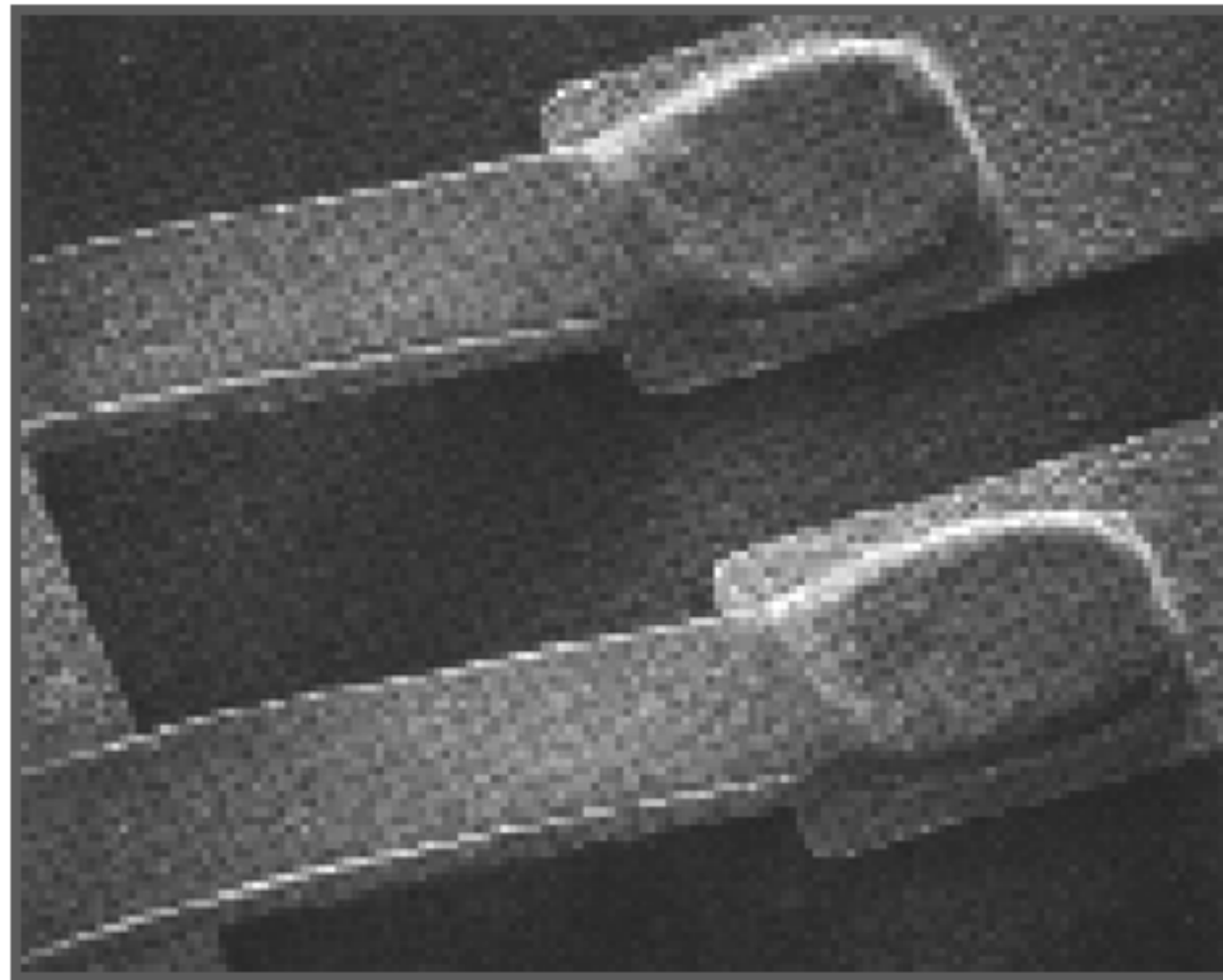


Beam Lead Transistors



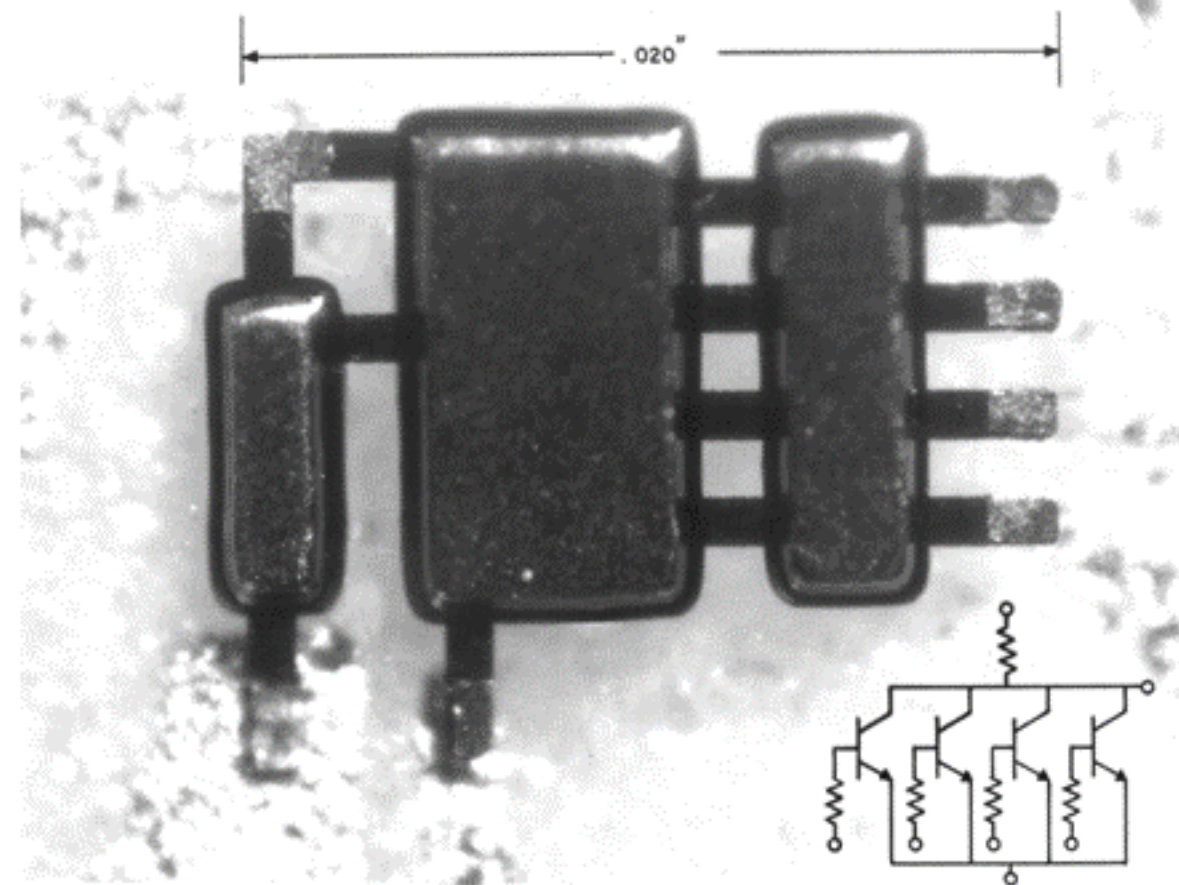
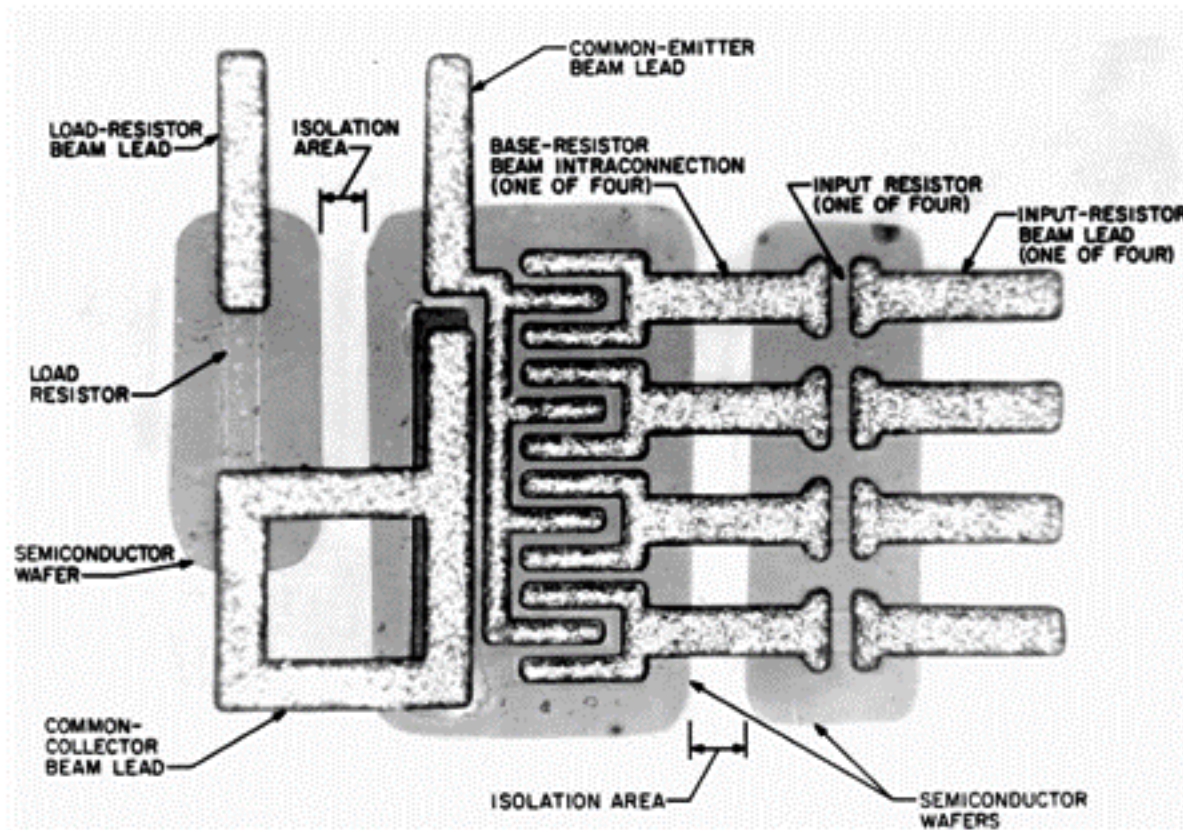
Optical micrograph of a section of an array of beam-lead transistors fabricated on a silicon wafer

Thermally-bonded beam-lead end connections



Scanning electron micrograph

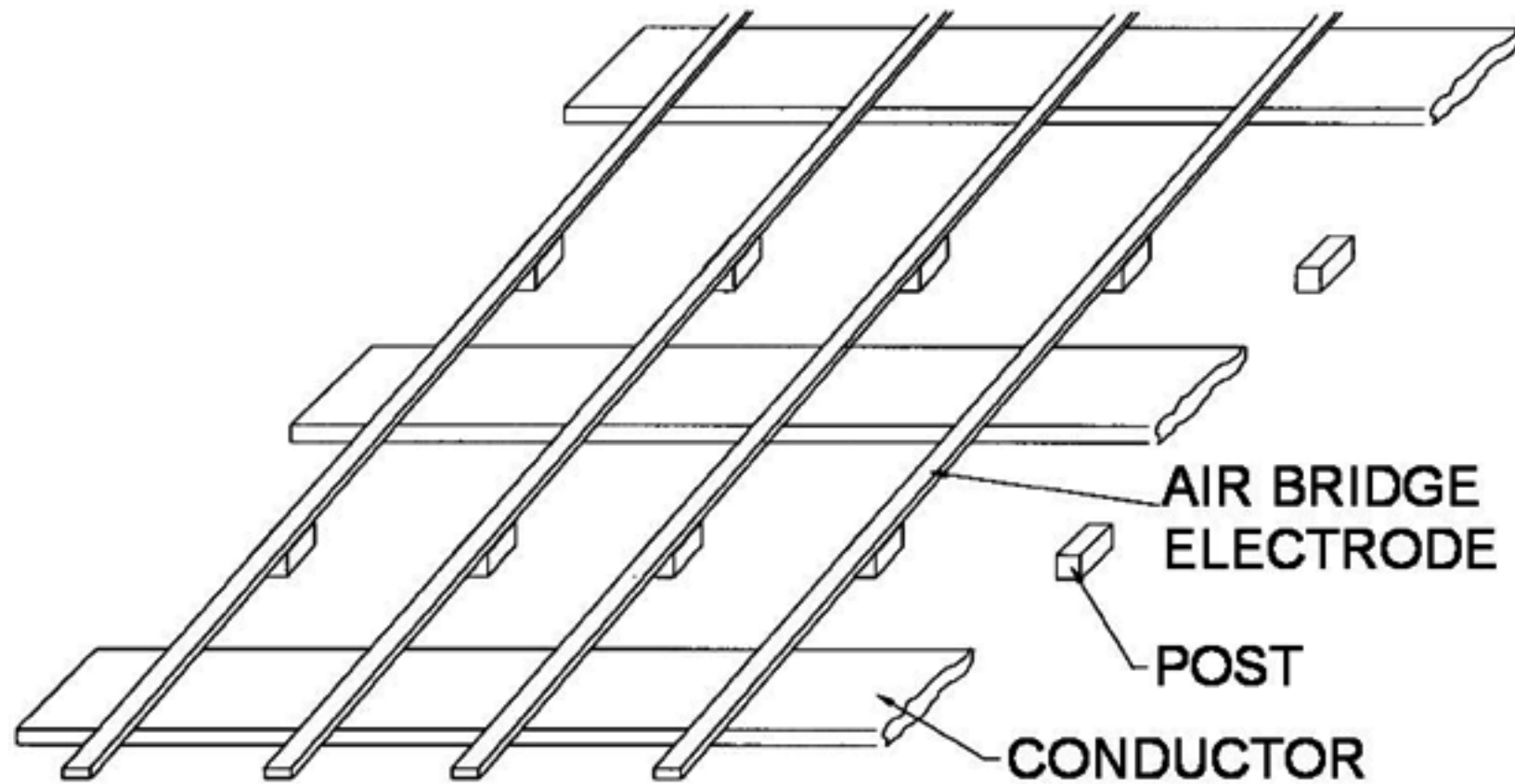
Monolithic Integrated Circuit



Among Marty's technology developments
were air-bridge **plasma displays**

low cost manufacture of lightweight
flat-panel plasma displays

Air-Bridge Plasma Displays



Flat panel electronics platform for plasma displays formed by microbridge cross connects

“... plasma display technology is superior for the following reasons ...”

Microbridge architecture

Enables low cost mass production

Ease and low-cost scalability to large sizes

For living rooms, auditoriums, arenas

High brightness – Long lifetime

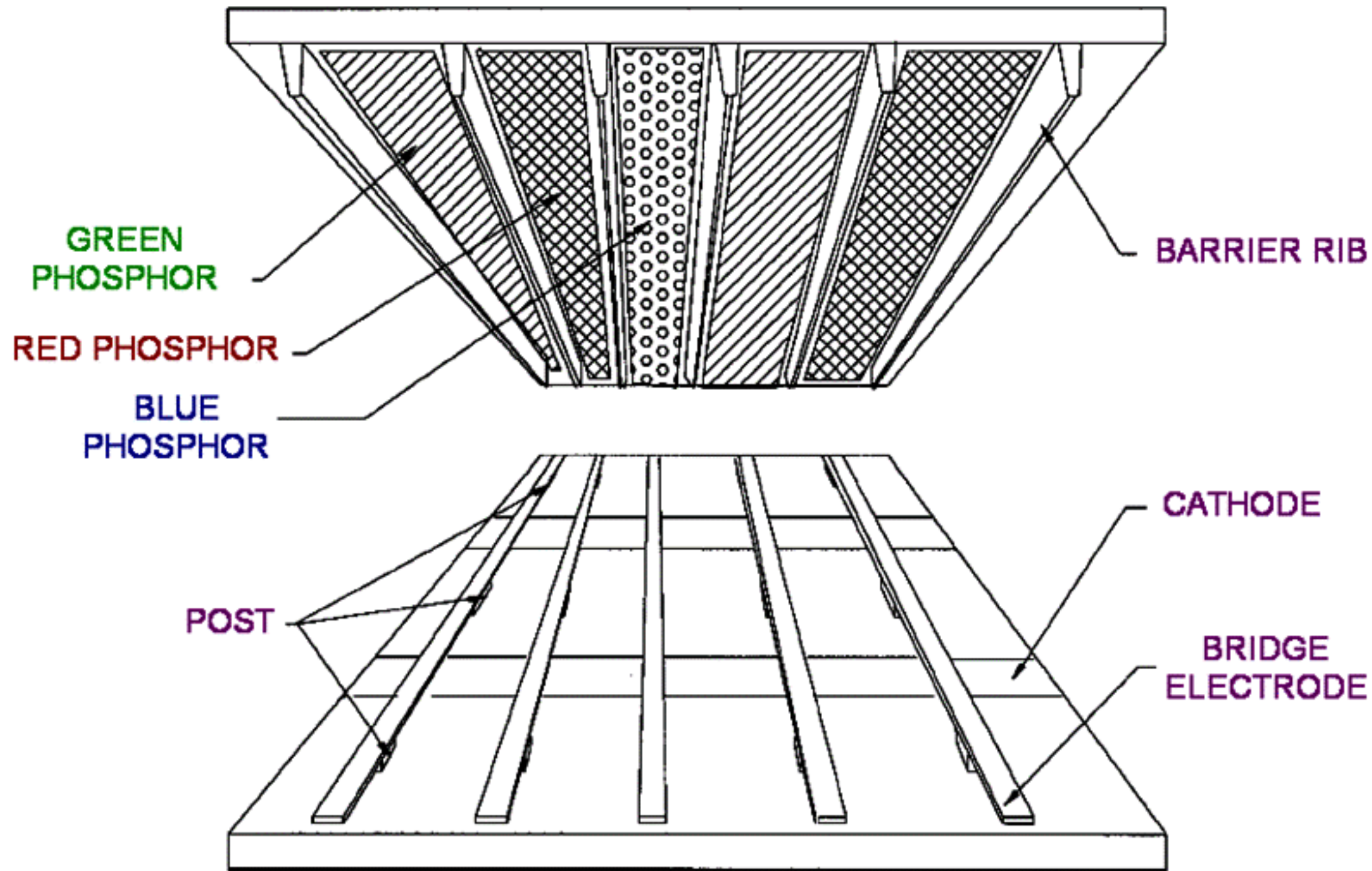
Like fluorescent lighting

Lightweight flat panels

As opposed to heavy, thick, bulky, and fragile

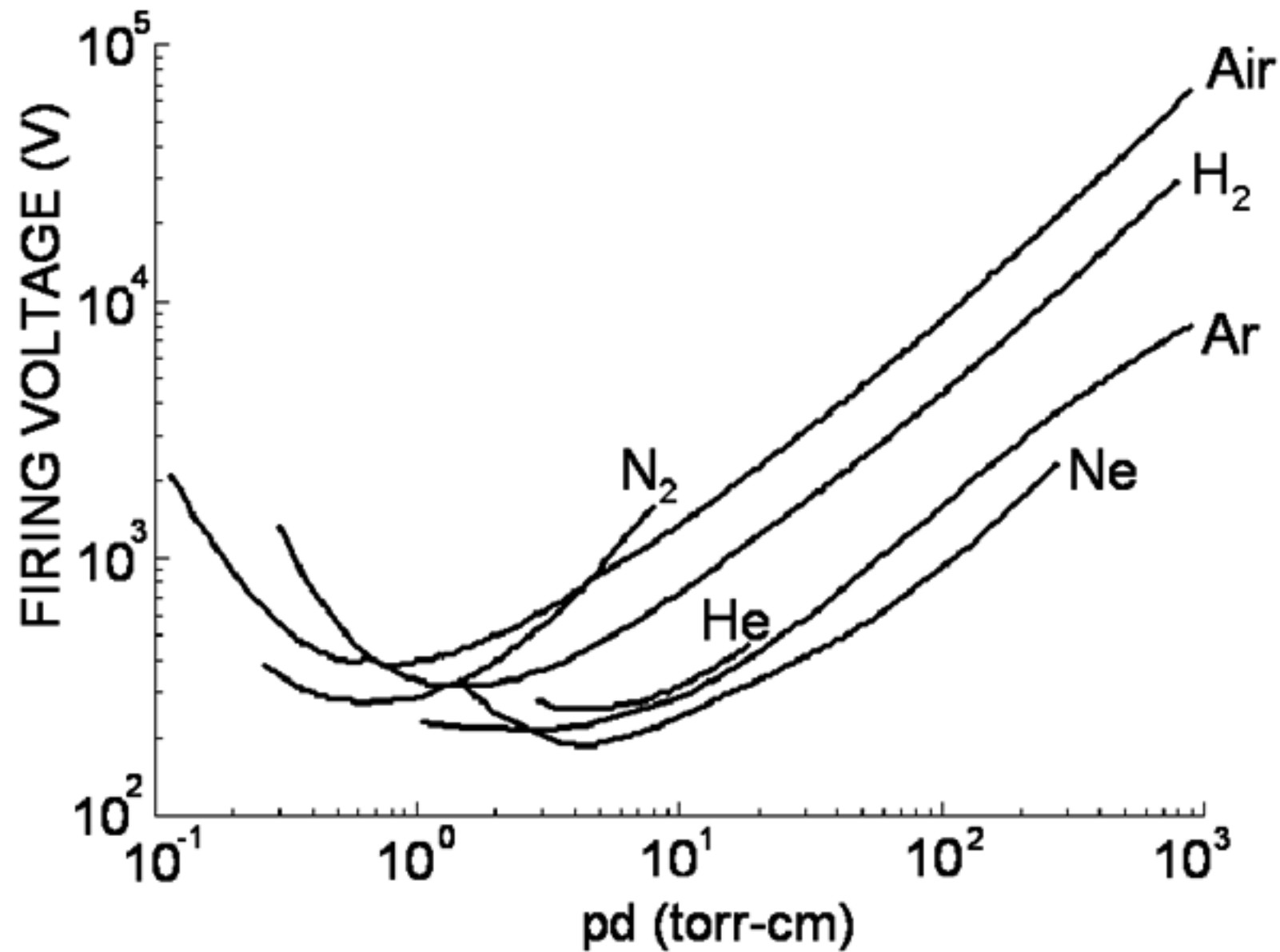
Spectron Corporation of America / **Hyundai**

Microbridge Structure for Pressurized Plasma Display Panel



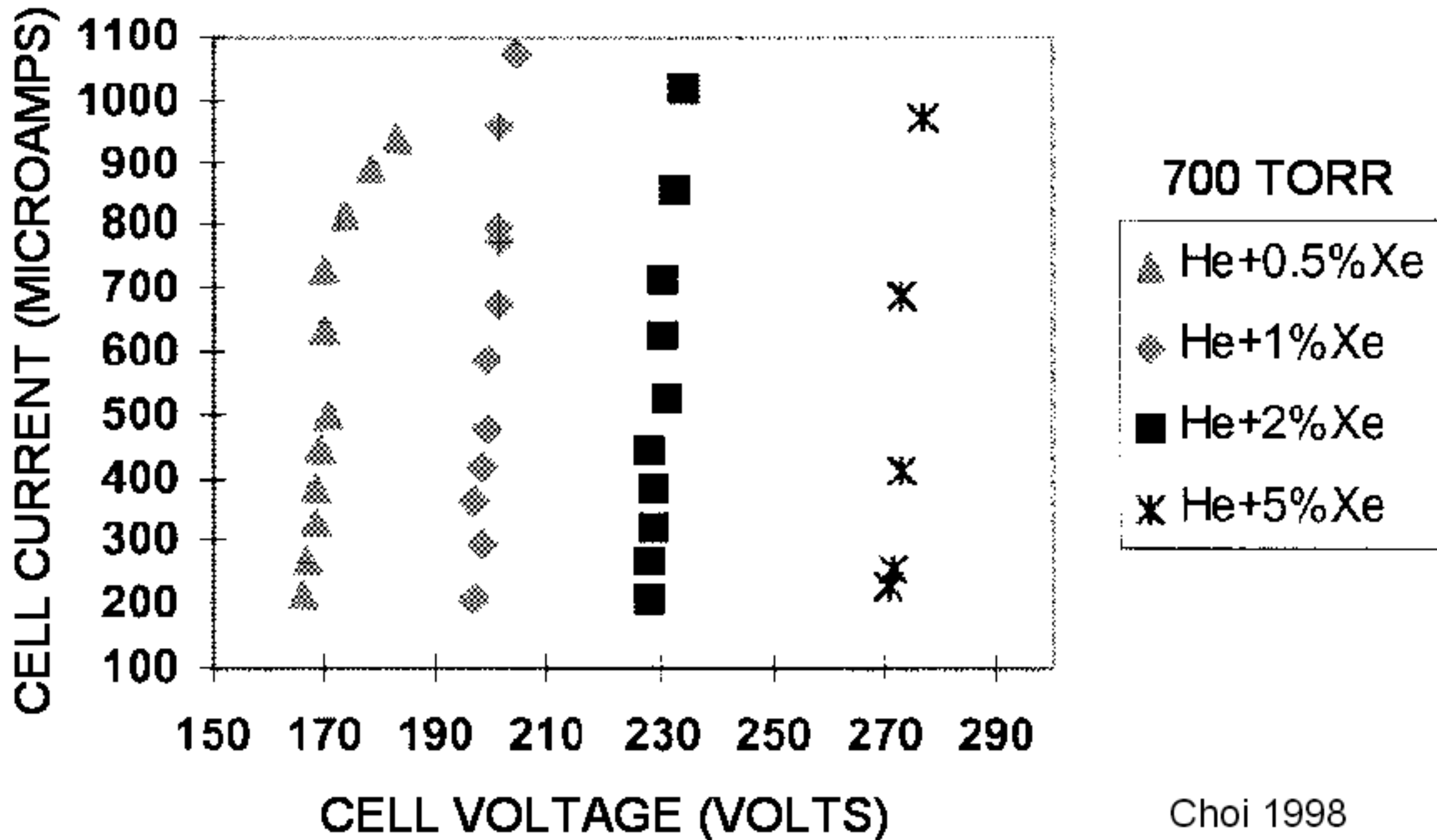
Cathode, bridge anode, support posts

Experimental Paschen's Law



Plasma discharge operation: at curve minimum

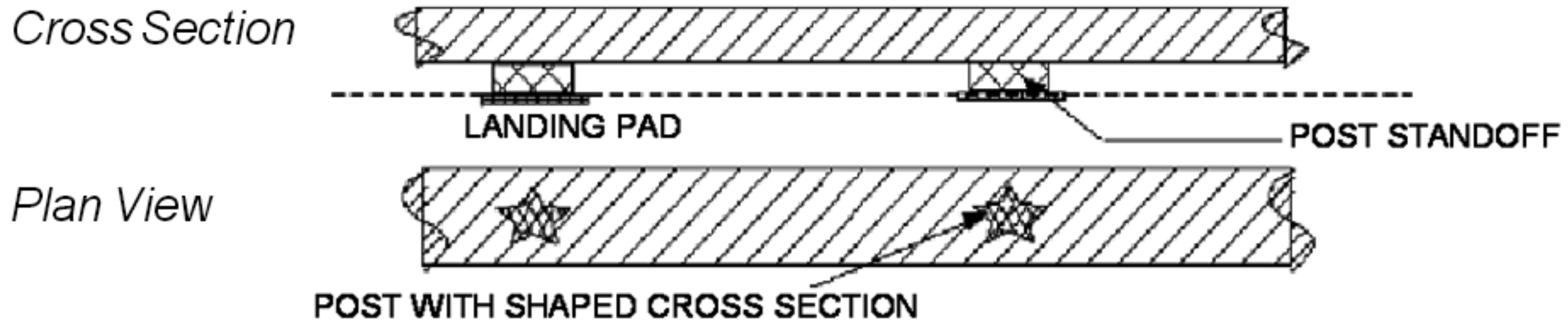
Plasma pixel I-V curves



Choi 1998

Magnetic Self Alignment

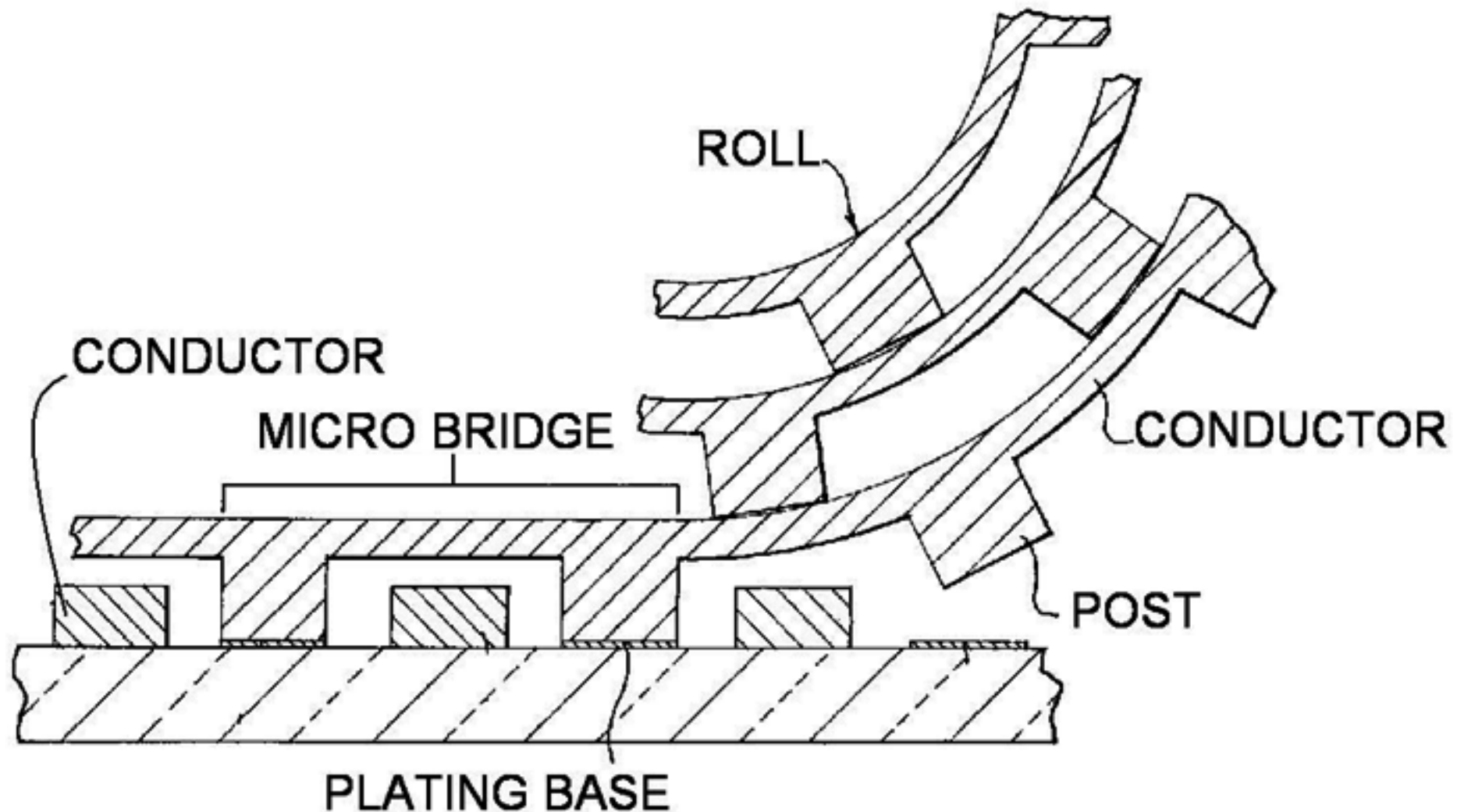
3-D Microbridge Structures on Substrate



Substrate forms the ground plane

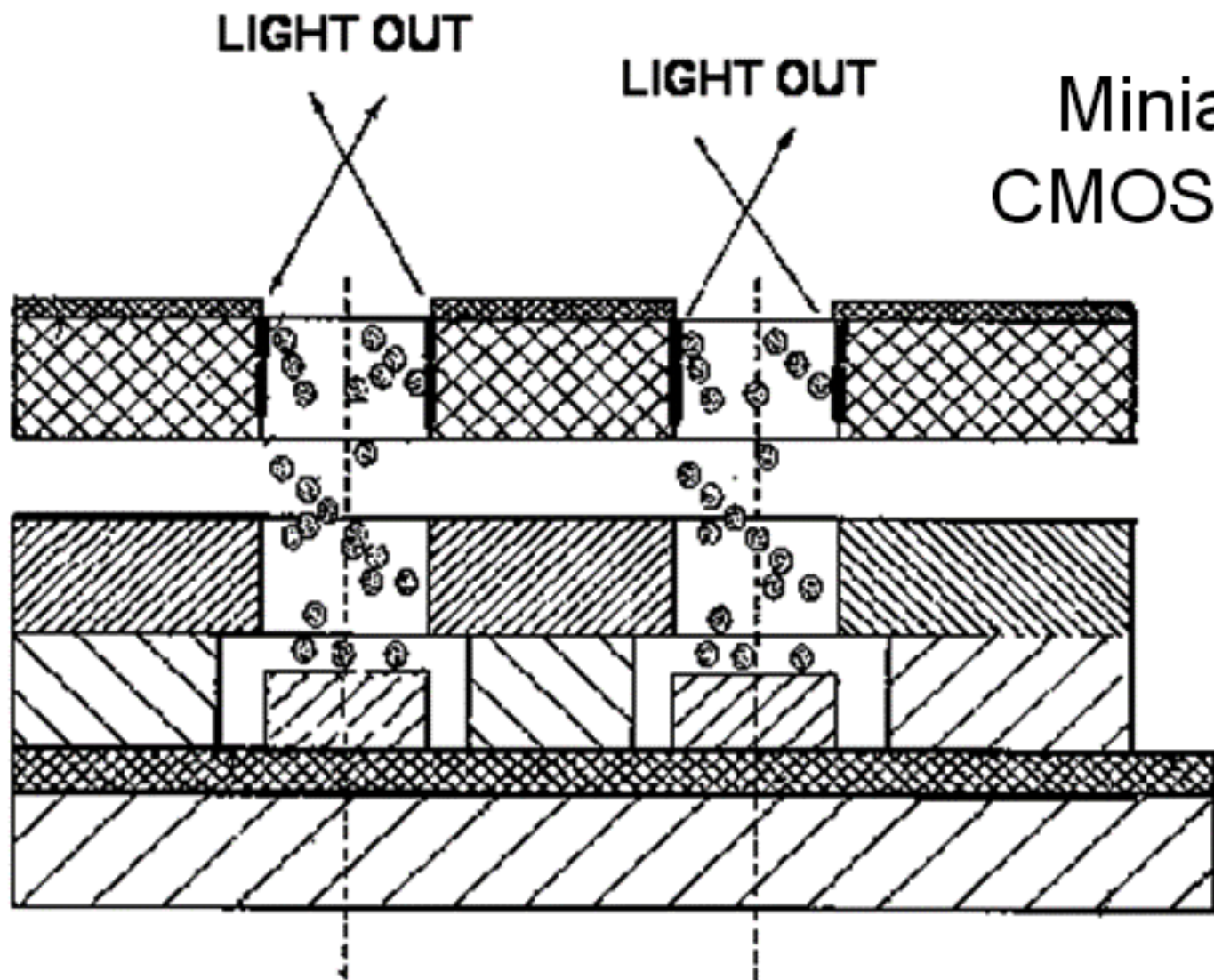
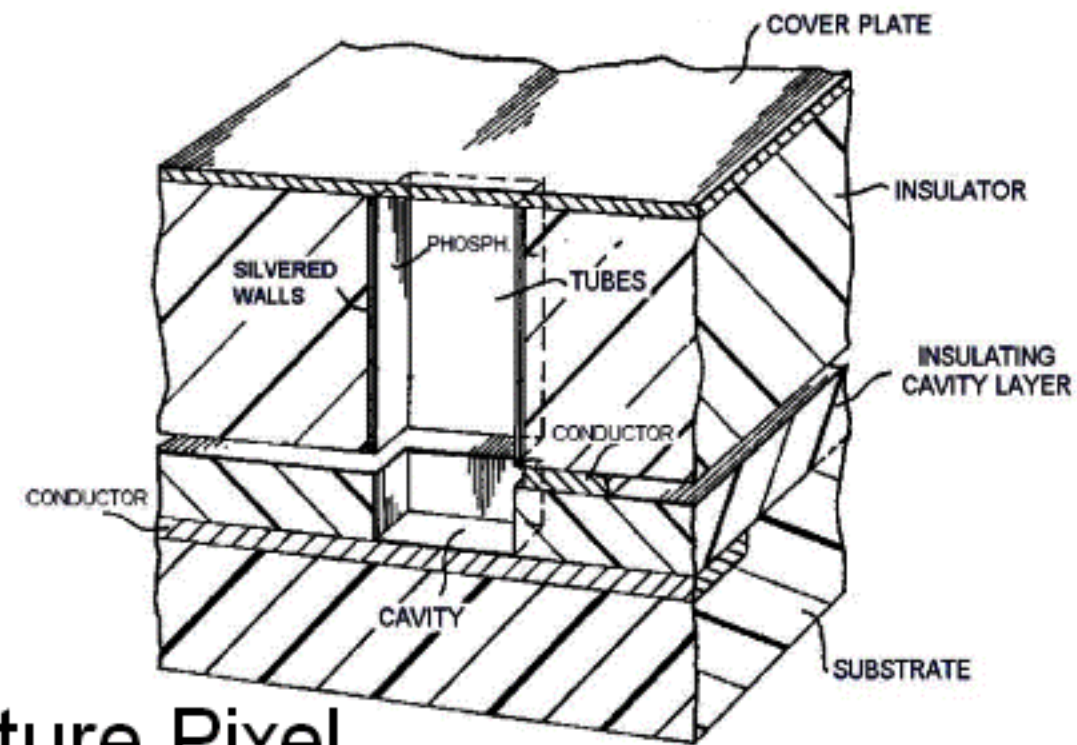
*Porcelain coated boronized steel • tight radii of curvature
wrinkle-proof • “bullet proof”*

Magnetic Self-Assembly

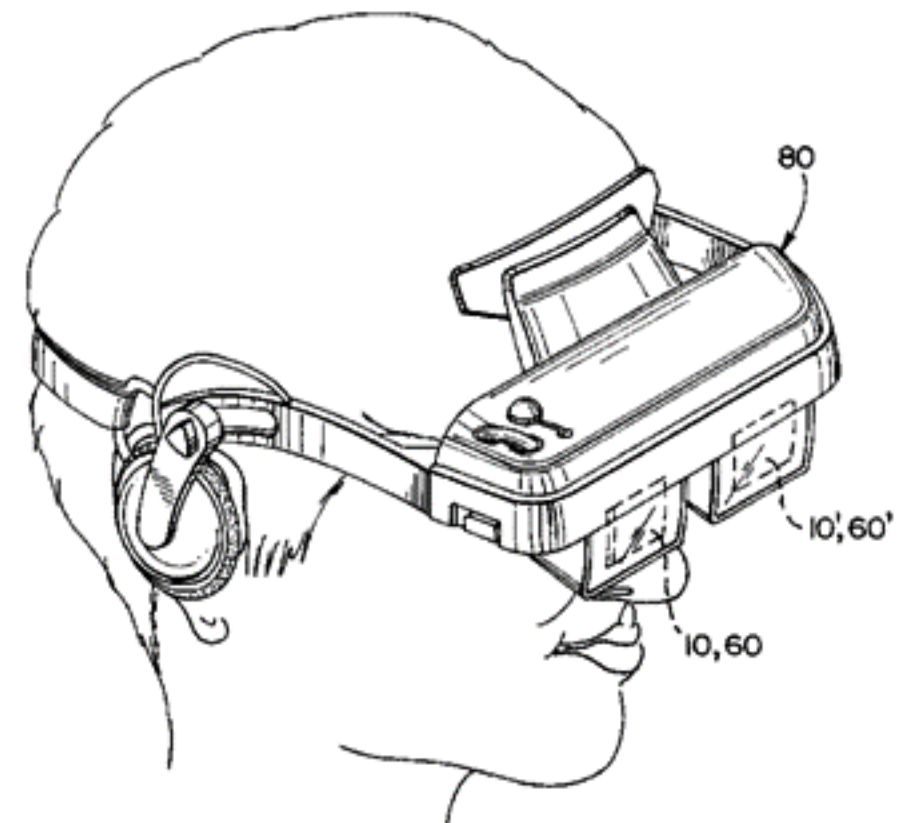


Magnetic self-assembly is used to fabricate microbridge cross conductors for interconnects in X-Y addressable arrays (flat-panel displays and other platforms)

Long-Lifetime Microplasma Gas Discharge Cell

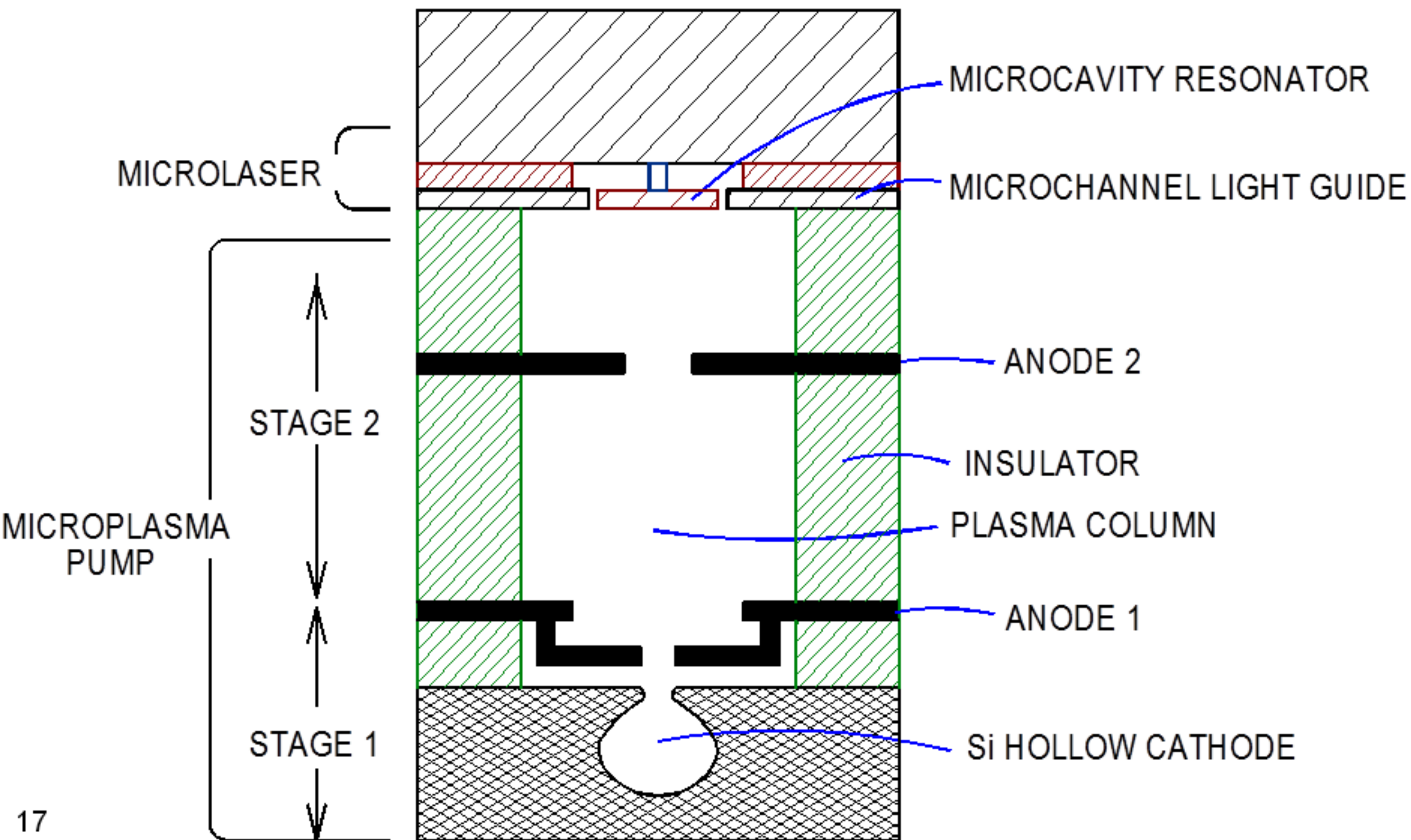


Miniature Pixel
CMOS Processing

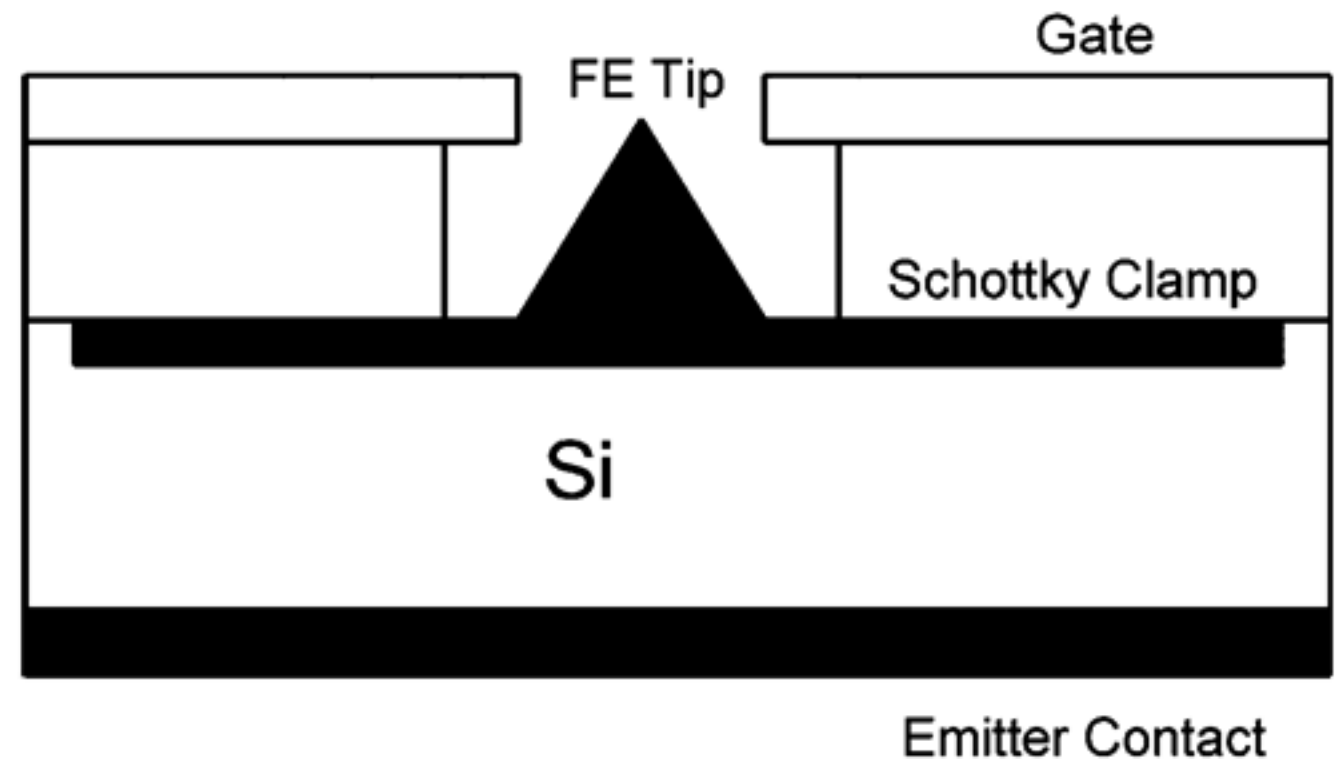
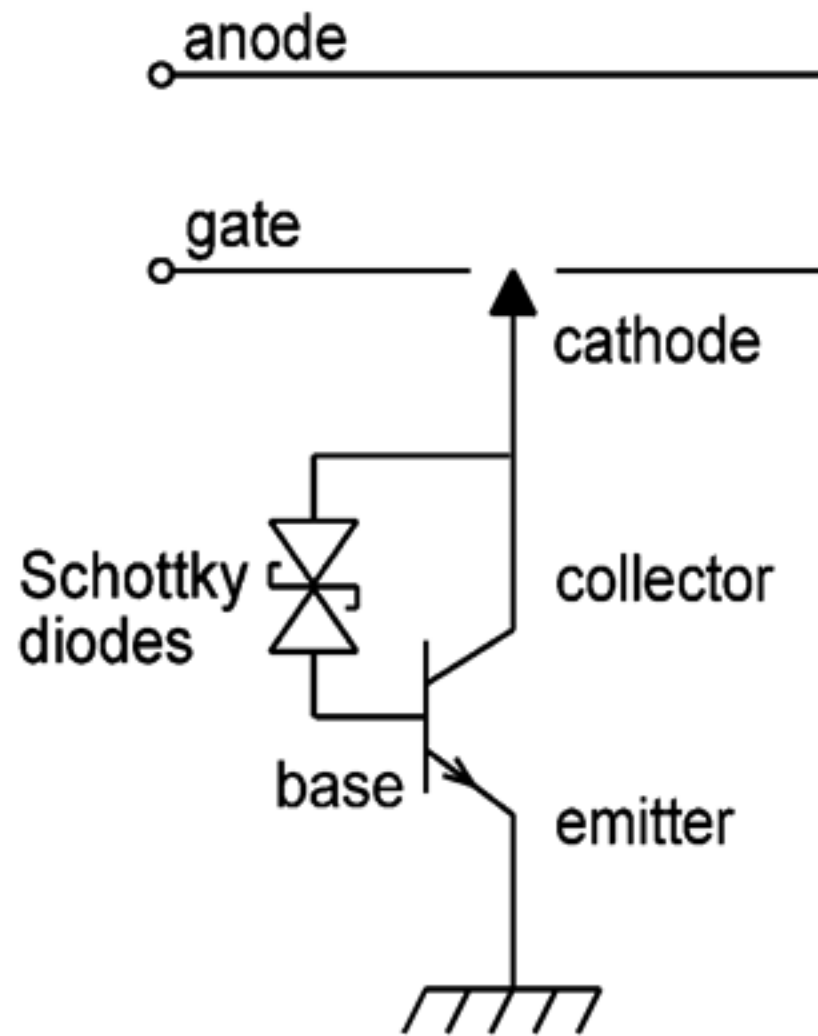


Heads Up Display – 3D Theater

Microplasma Light Source Silicon-MEMS



High-Current Electron Beam Auto-Regulated Field Emission Array



Schottky-clamped bipolar transistor

$$J_{FEA} = f \beta J_B$$

Emission current at the field tip (cathode) is determined by the product of the bipolar transistor gain ($\beta \approx 100$) and the current injected into the base.

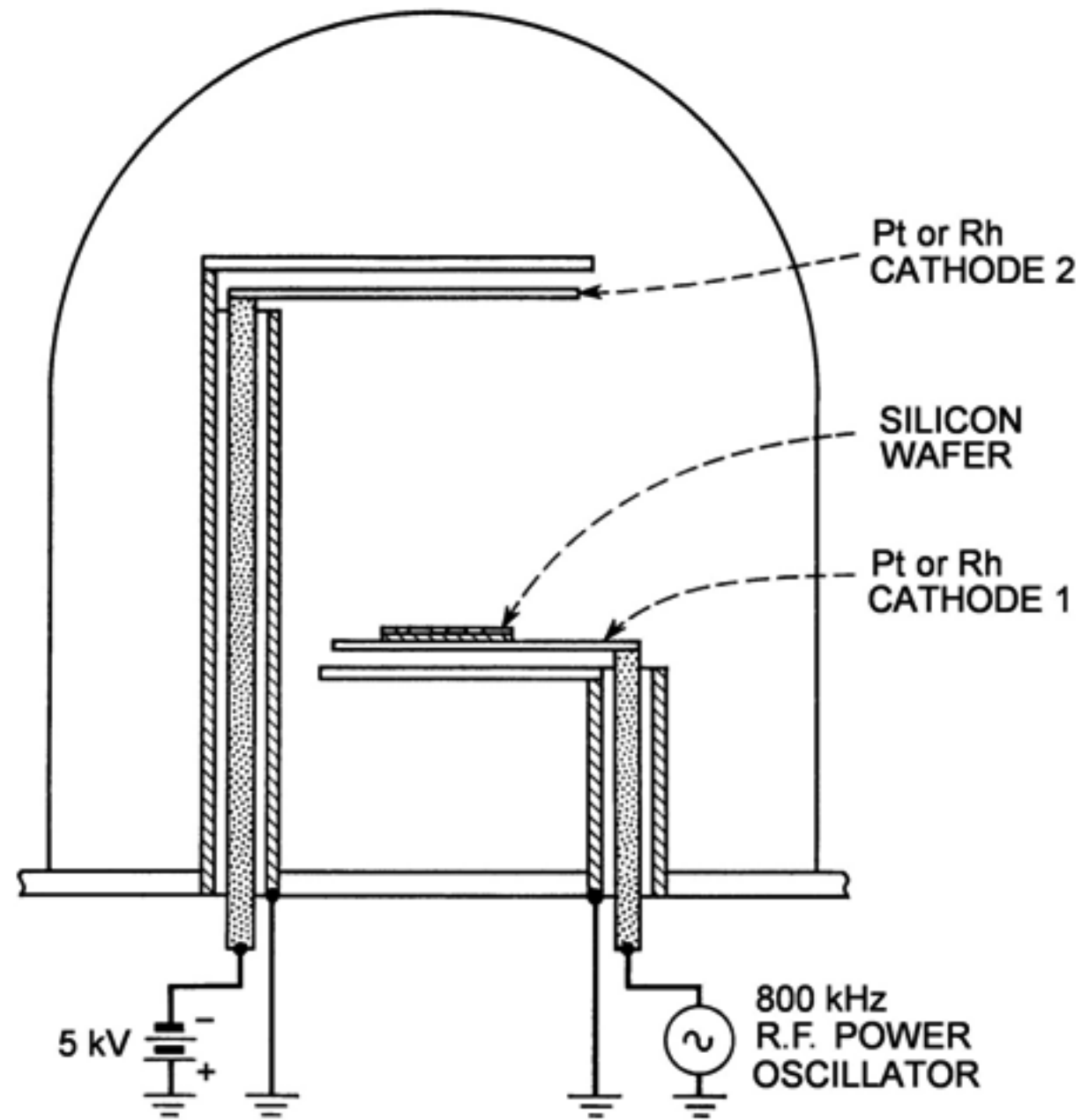
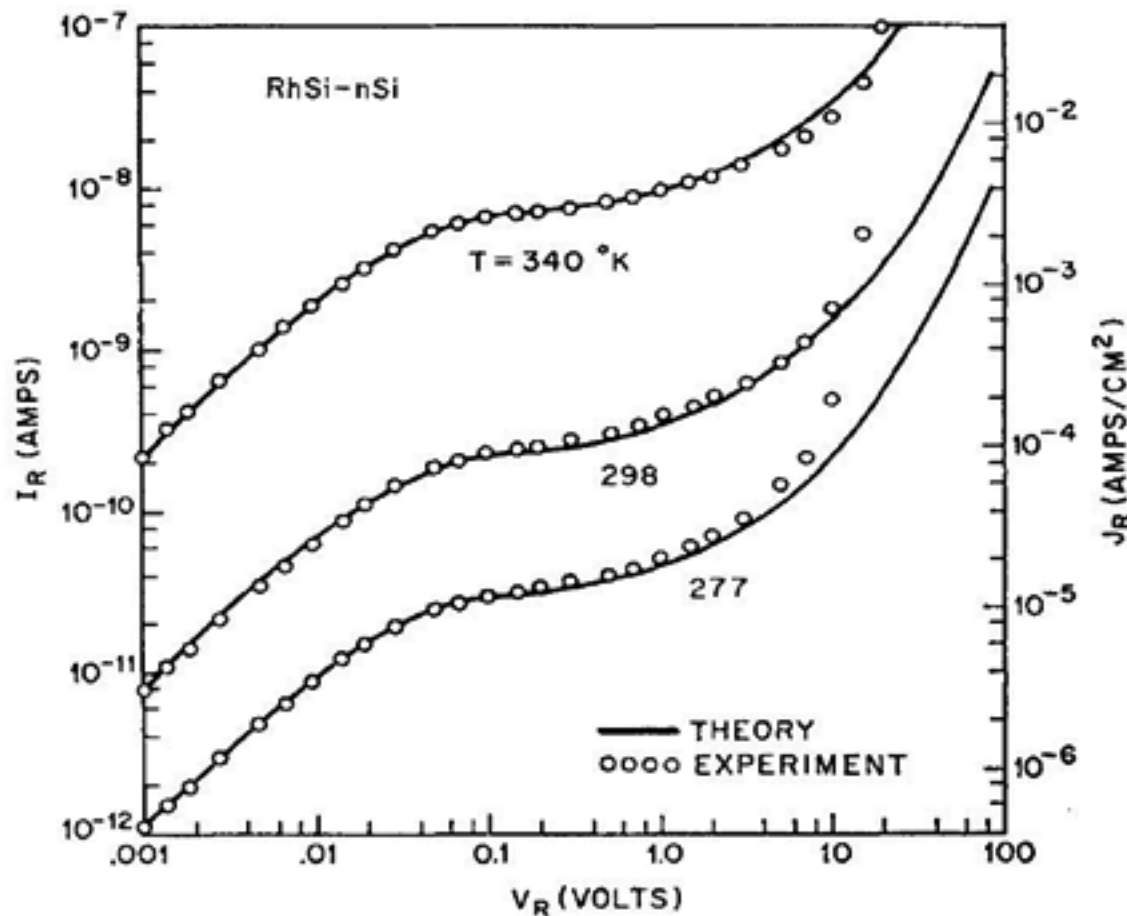
Base current is determined by the **saturation thermionic emission current** of the Schottky-barrier junction ($\pm 5\%$ in massively parallel field-emission array).

Ultra-Low Energy Ion Implantation

150-eV Plasma Immersion
Ion Implantation

Implemented as
biased r.f. sputtering

Used to produce nearly ideal RhSi
and PtSi Schottky-barrier diodes

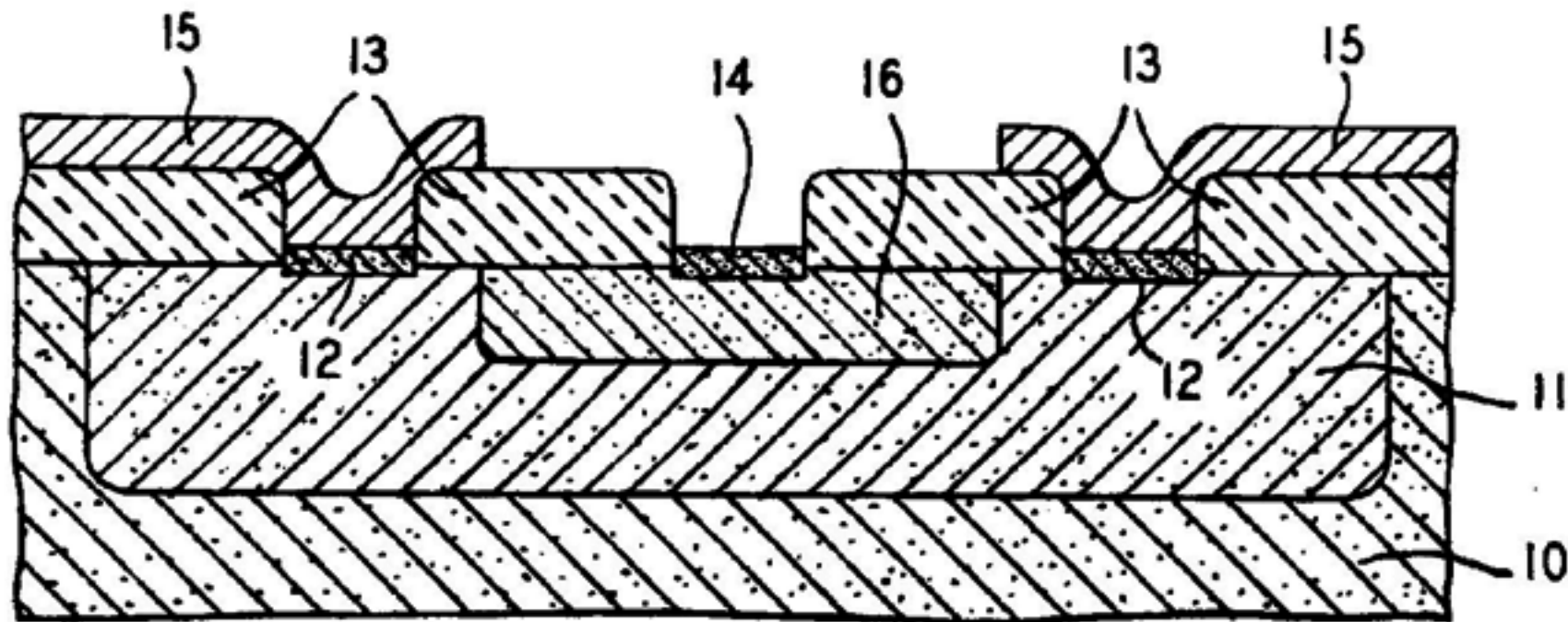


PtSi Schottky-Barrier Devices

Ultra-shallow PtSi Contacts

Very shallow, sharp emitter profiles

Low link-up resistance

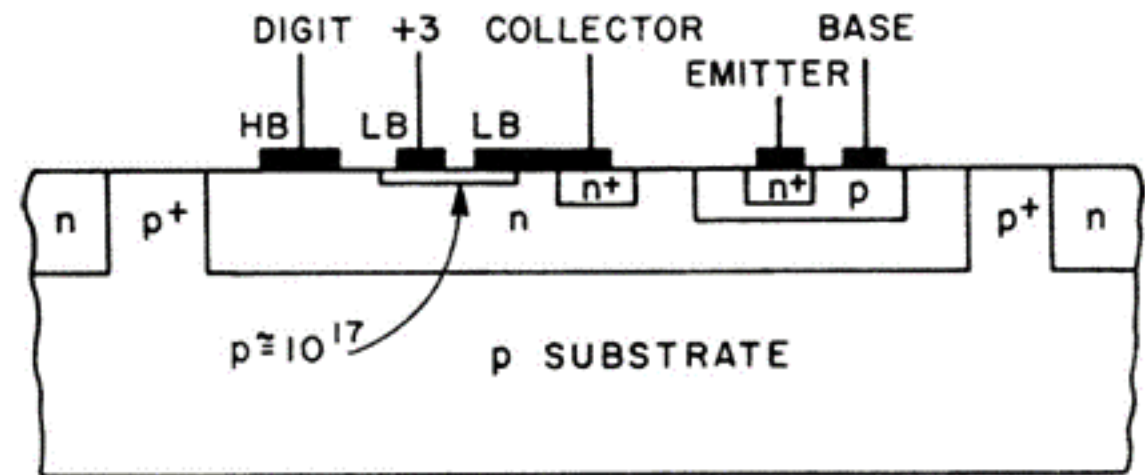


High frequency bipolar transistor using PtSi contacts.

RhSi Schottky-Barrier Technology

Bipolar transistor memory cell

High barrier (RhSi-pSi)
and low barrier (RhSi-nSi) contacts



Uncooled High Speed RhSi-nSi Phototransistor Detectors / Imaging

$$\phi_B = 0.69 \pm 0.01 \text{ eV}$$

$$\lambda_c \approx 1800 \text{ nm}$$

1550 nm receiver

25% capture efficiency

2% internal quantum efficiency

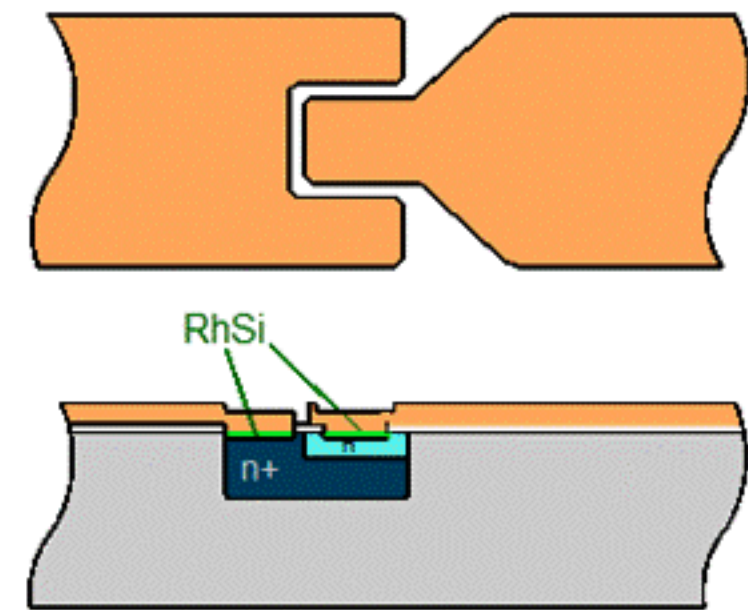
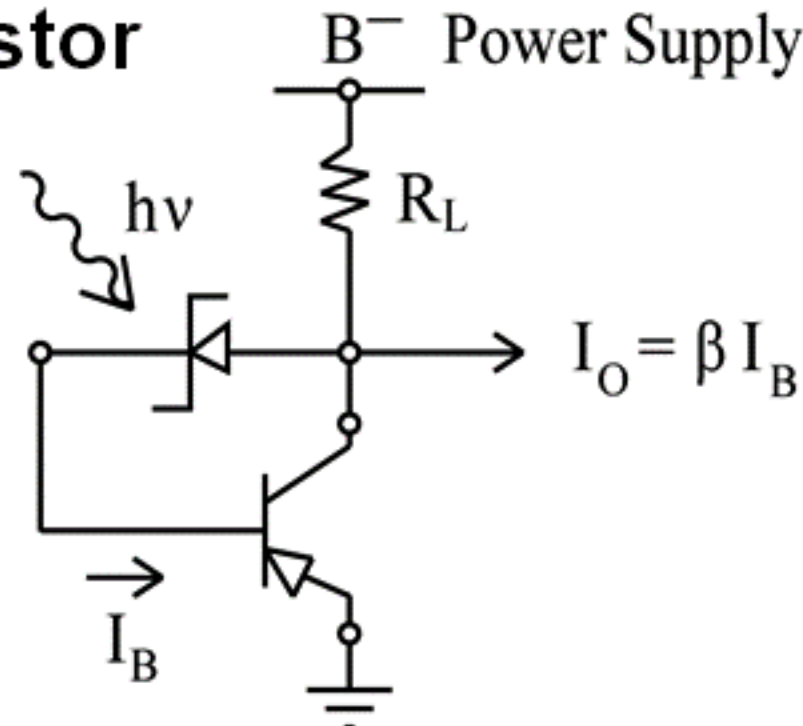
20 mA/W responsivity

40 S/N for -20 dBm optical input

40 Gb/s

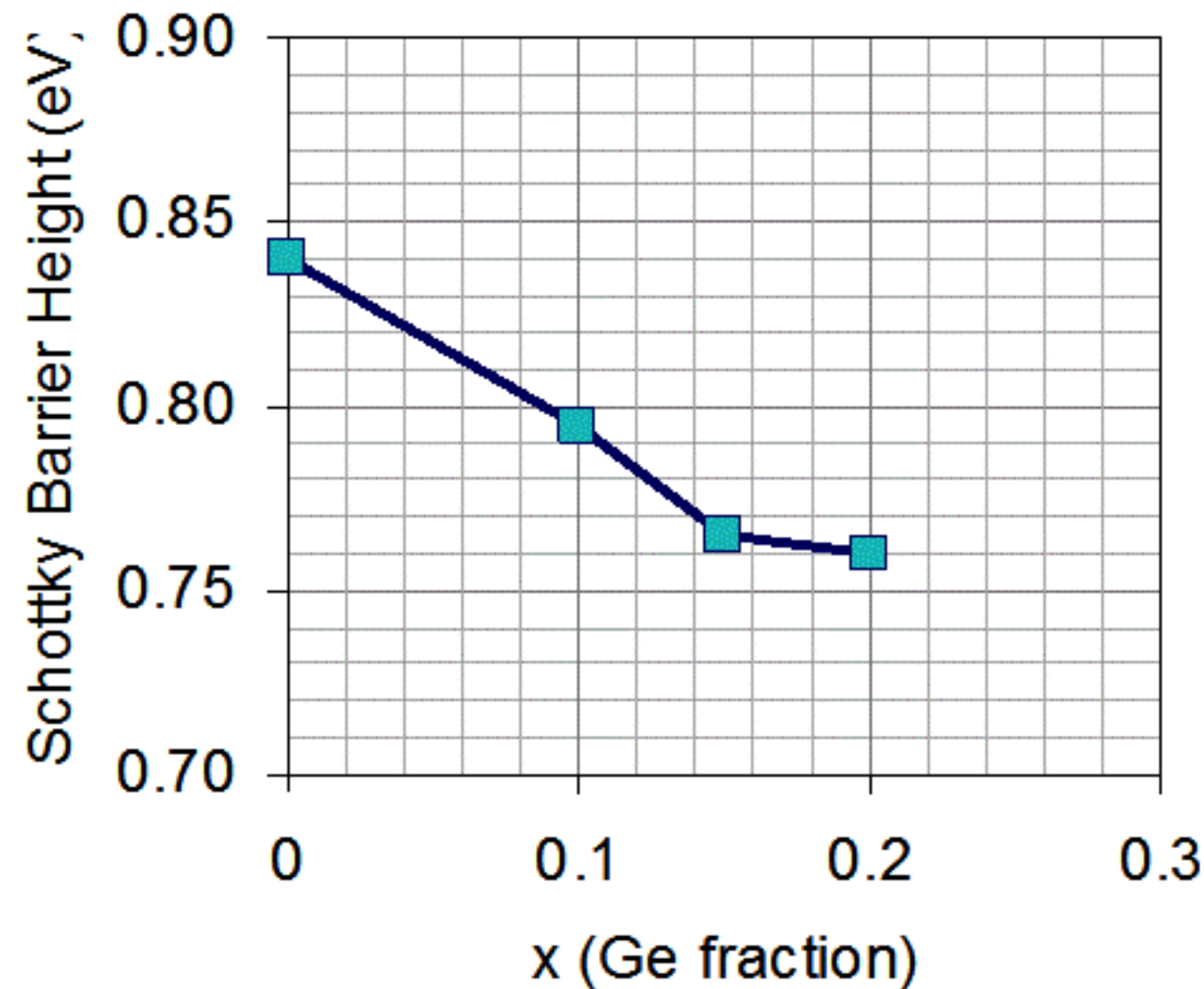
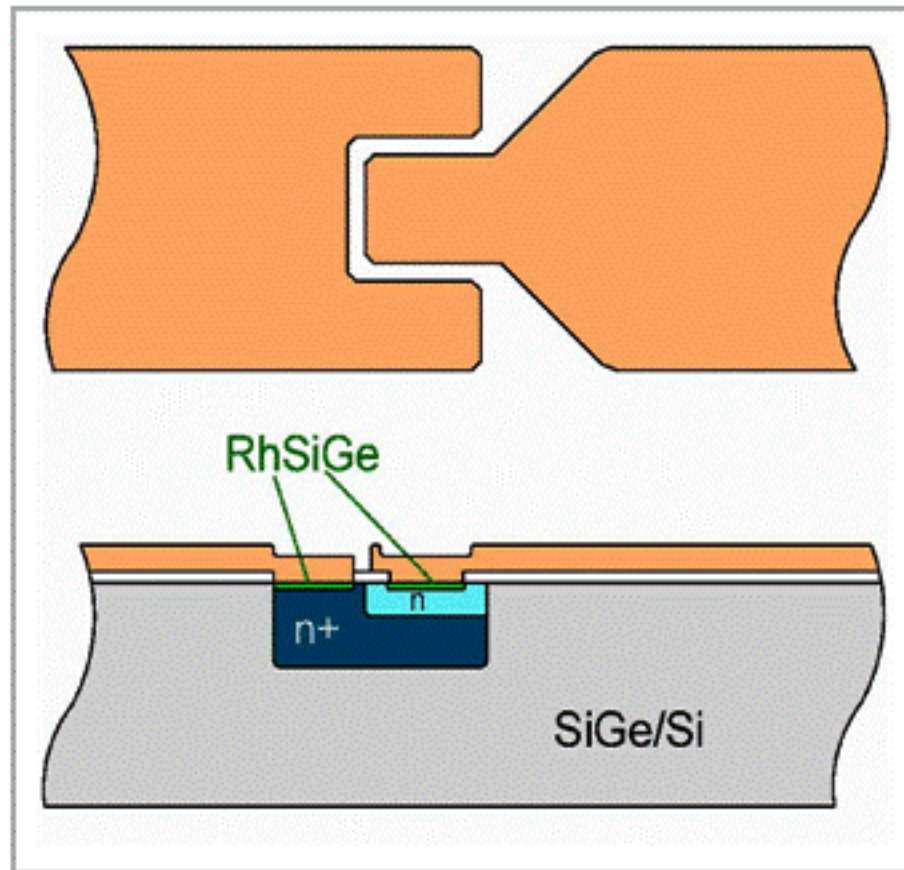
10^{-12} bit error rate

at 38.5 μ W optical power input



Silicide	ϕ_B nSi	ϕ_B pSi
RhSi	0.69	0.34
PtSi	0.84	0.26

Rh / Si-Ge Pt / Si-Ge

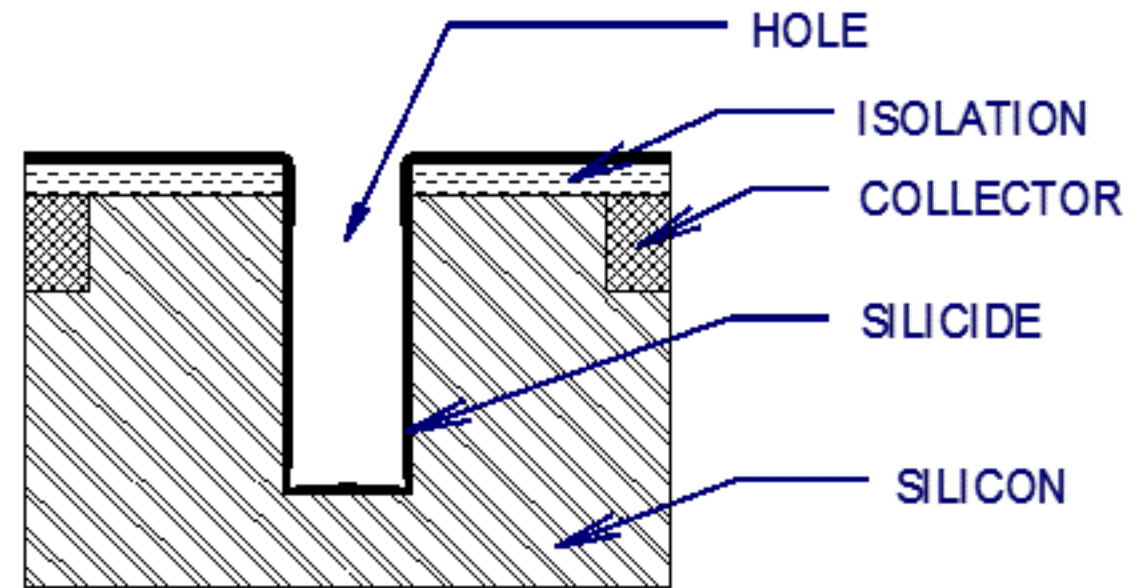
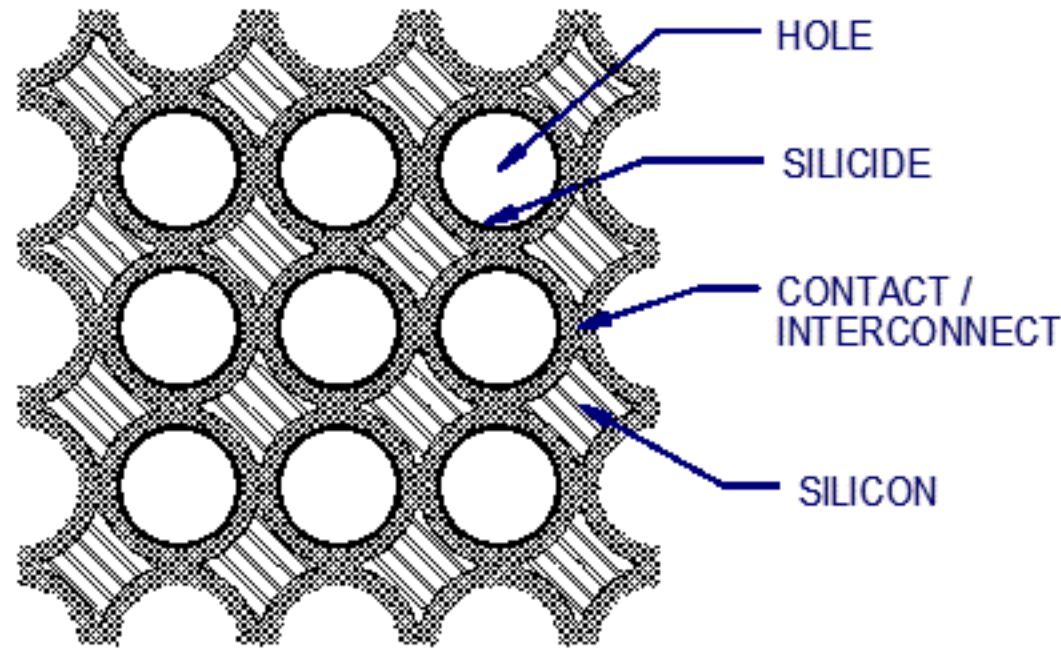


Front-side contact configuration of $\text{RhSi}_{1-x}\text{Ge}_x/\text{Si}_{1-x}\text{Ge}_x$ photo detector
 For n-type: $\text{RhSi}_{1-x}\text{Ge}_x$ areas form the $\text{RhSi}_{1-x}\text{Ge}_x/n^+\text{Si}_{1-x}\text{Ge}_x$ and $\text{RhSi}_{1-x}\text{Ge}_x/n^-\text{Si}_{1-x}\text{Ge}_x$ contacts. Dimensions expanded for illustration. Metallization isolated by oxide.

PtSi / n- $\text{Si}_{1-x}\text{Ge}_x$ contacts

Schottky barrier height at 2V reverse bias vs Ge fraction x

Radiation-Hardened Infrared Schottky Detectors

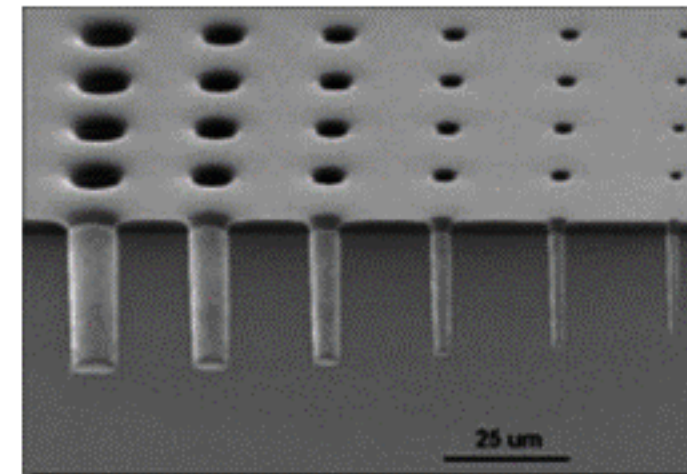


Arrayed photon trap re-entrant Schottky barrier detector

Walls of the holes act as the Schottky barrier devices

Emitter and collector contacts and (crossed linear)

interconnects are separated by isolation oxide film



Advantages of Rh

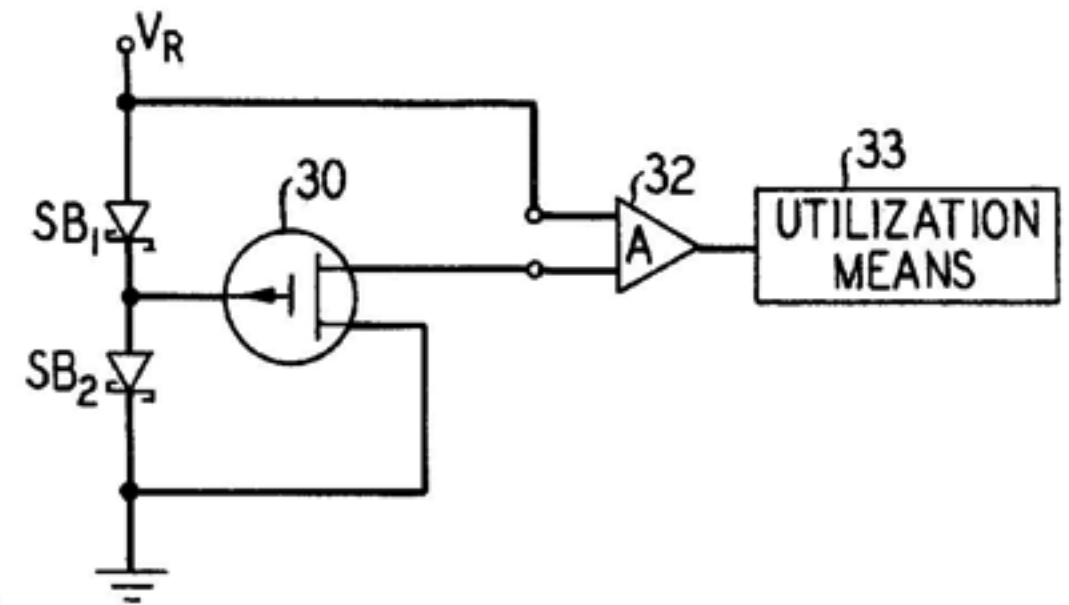
- Superior corrosion resistance
- Oxidation resistance
- Metal work function tuning
- Electroforming and electroplating
- Electromigration resistance
- Passive bioelectronics electrodes
- CMOS compatible

Advantages of RhSi

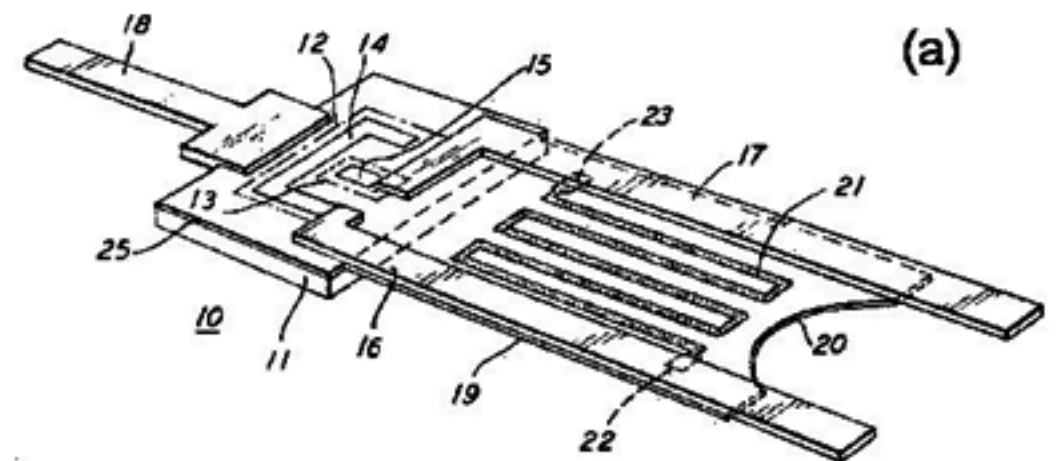
- RhSi stoichiometric stable phase
- $R_S = 1 \Omega/Sq$ nanoscale metallization
- Radiation hard electronics
- High quality Schottky barrier junctions
- Nanoscale structure stability
- Deposition / RTP integration
- CMOS compatible

Schottky-Barrier MEMS Devices

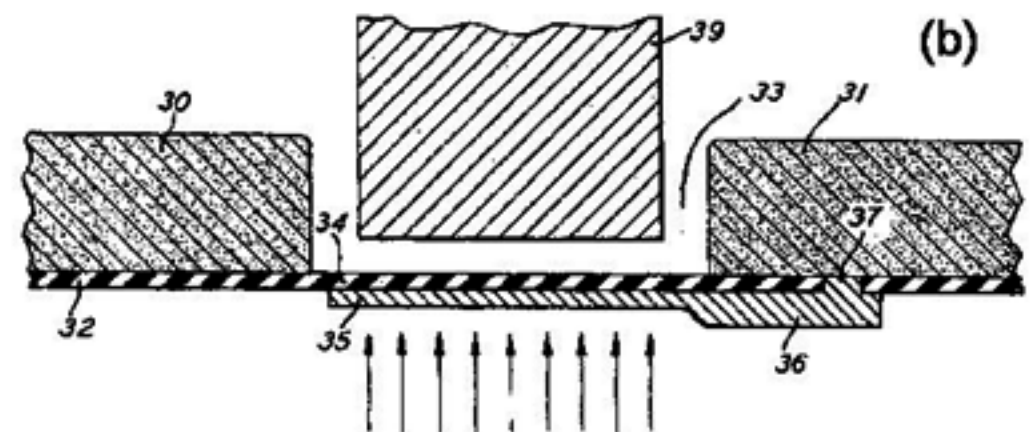
Differential Schottky-Barrier Diode MEMS Temperature Sensor



MEMS Thermal Isolation Circuit
Semiconductor circuit on thin low thermal conductivity membrane



Infrared bolometric sensor



High Gray Scale Resolution X-ray Imaging

Flexible Electronic X-ray Array Detector
(electronic x-ray “film”)

Technology Synergetics

Beam-Lead Air-Bridge Platform

Flexible Metal Substrate

Magnetic Self Assembly

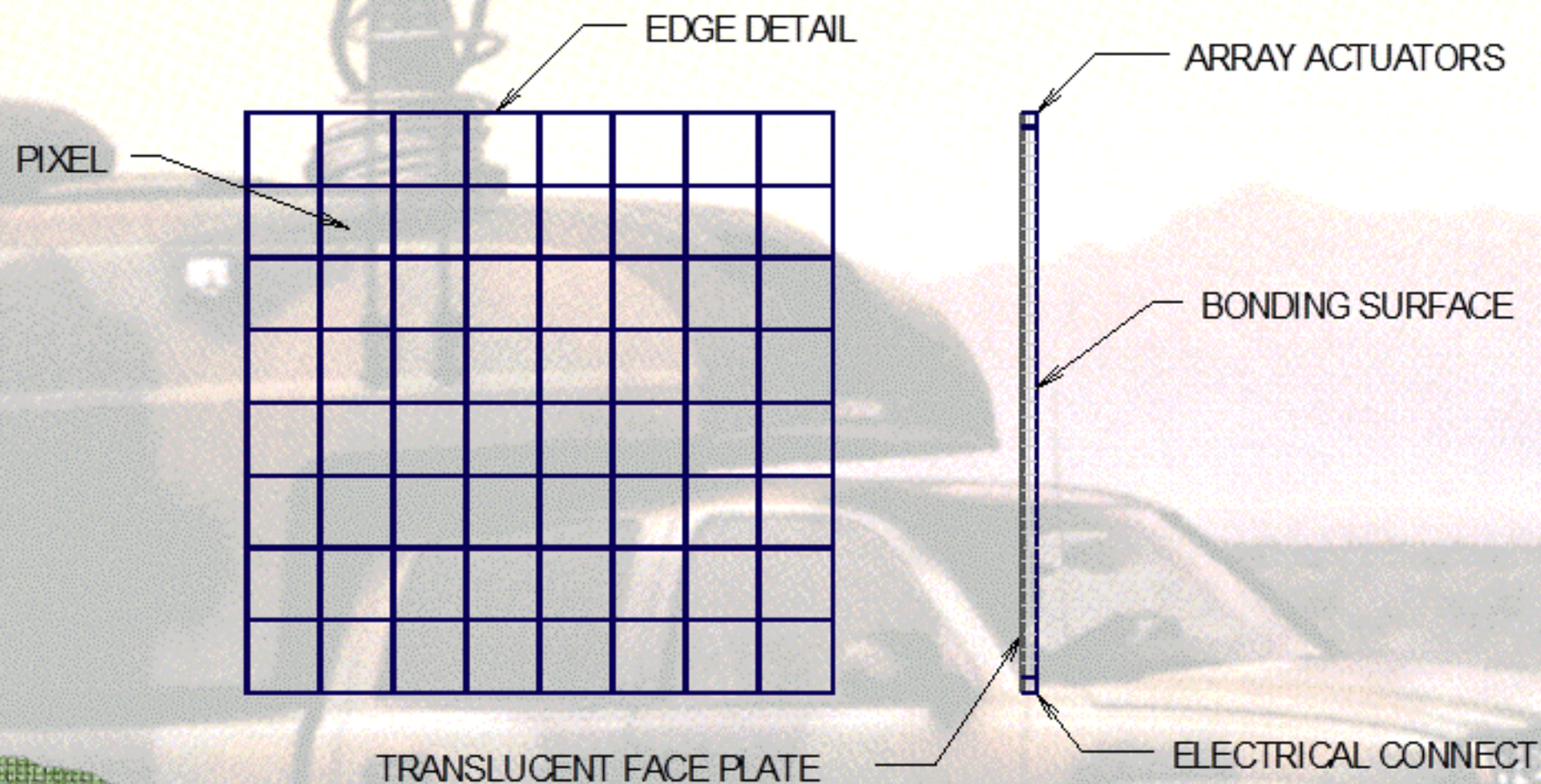
Transistorized Beam-Lead PtSi Detector

PtSi pixels

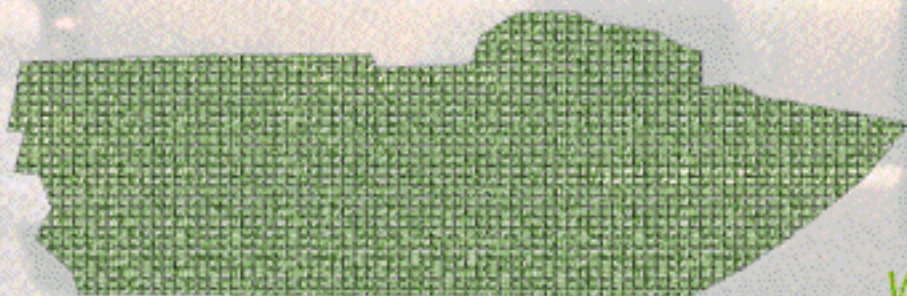
High barrier height

Avalanche multiplication

Electronic Adaptable Camouflage

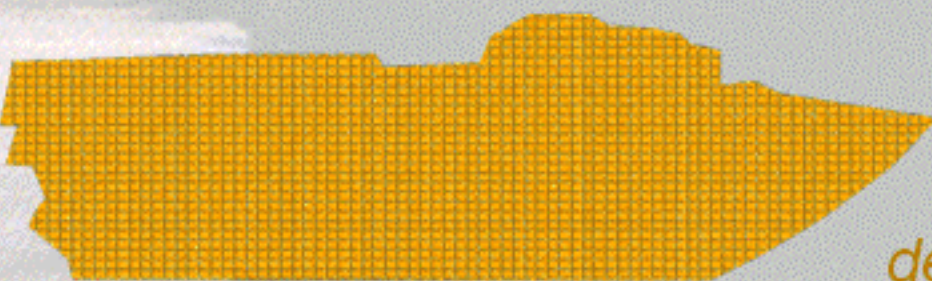


Camouflage display panel module



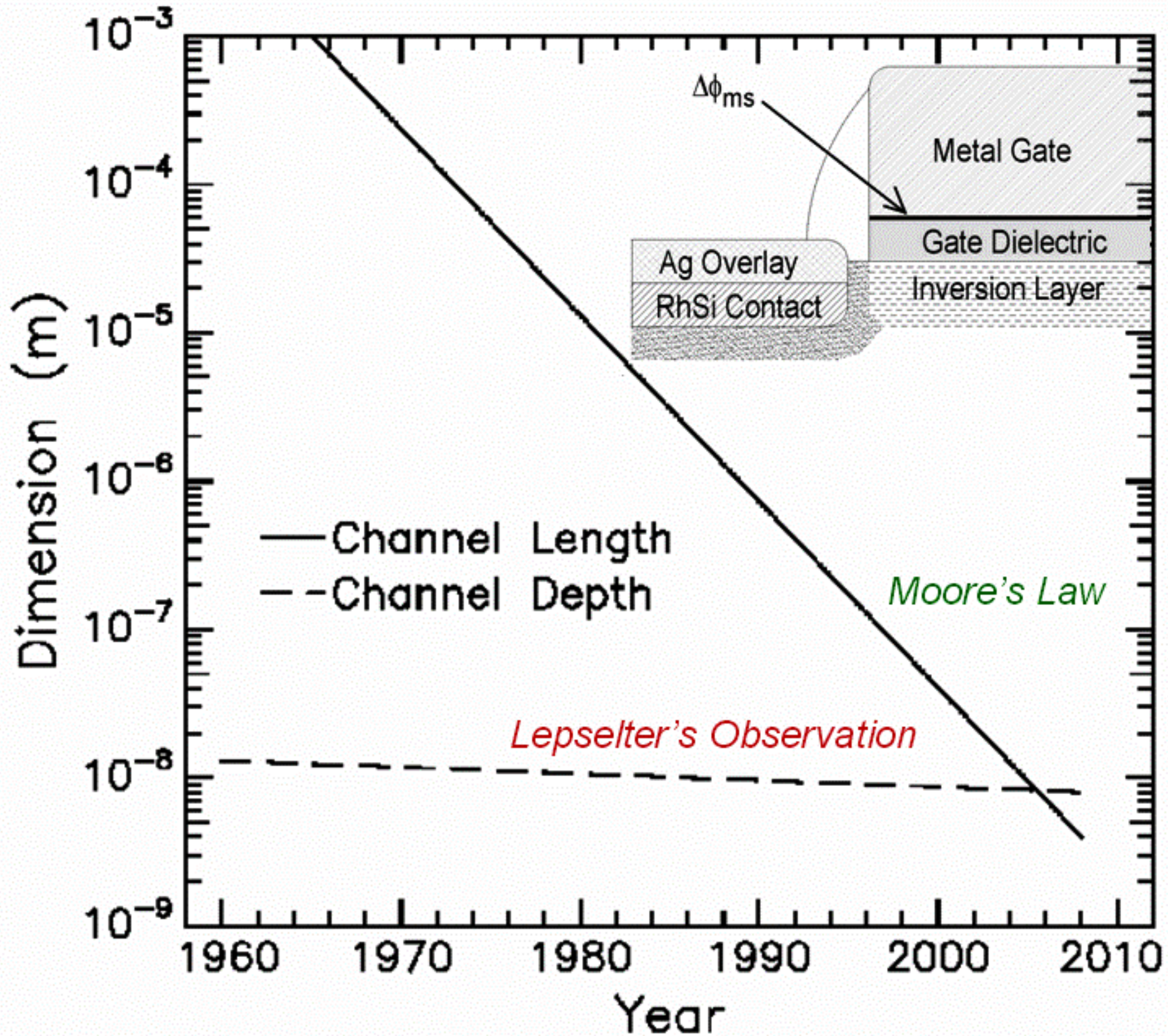
woodland

Adaptive mind-altering passive-reflective pixel elements
(camouflage detail pattern may be added)



desert

MOSFET Scaling



Environment ♦ *Power*

Environmental

Trash separation and recycling

Completely biodegradable marine garbage bags

Energy Storage

CMOS/metallization inspired super capacitors

Mobility fly wheels

Energy Distribution

Data Pump GatewayMeter™

Energy Recapture

Carnot-cycle engine waste heat

High efficiency thermo-electronic solar panel