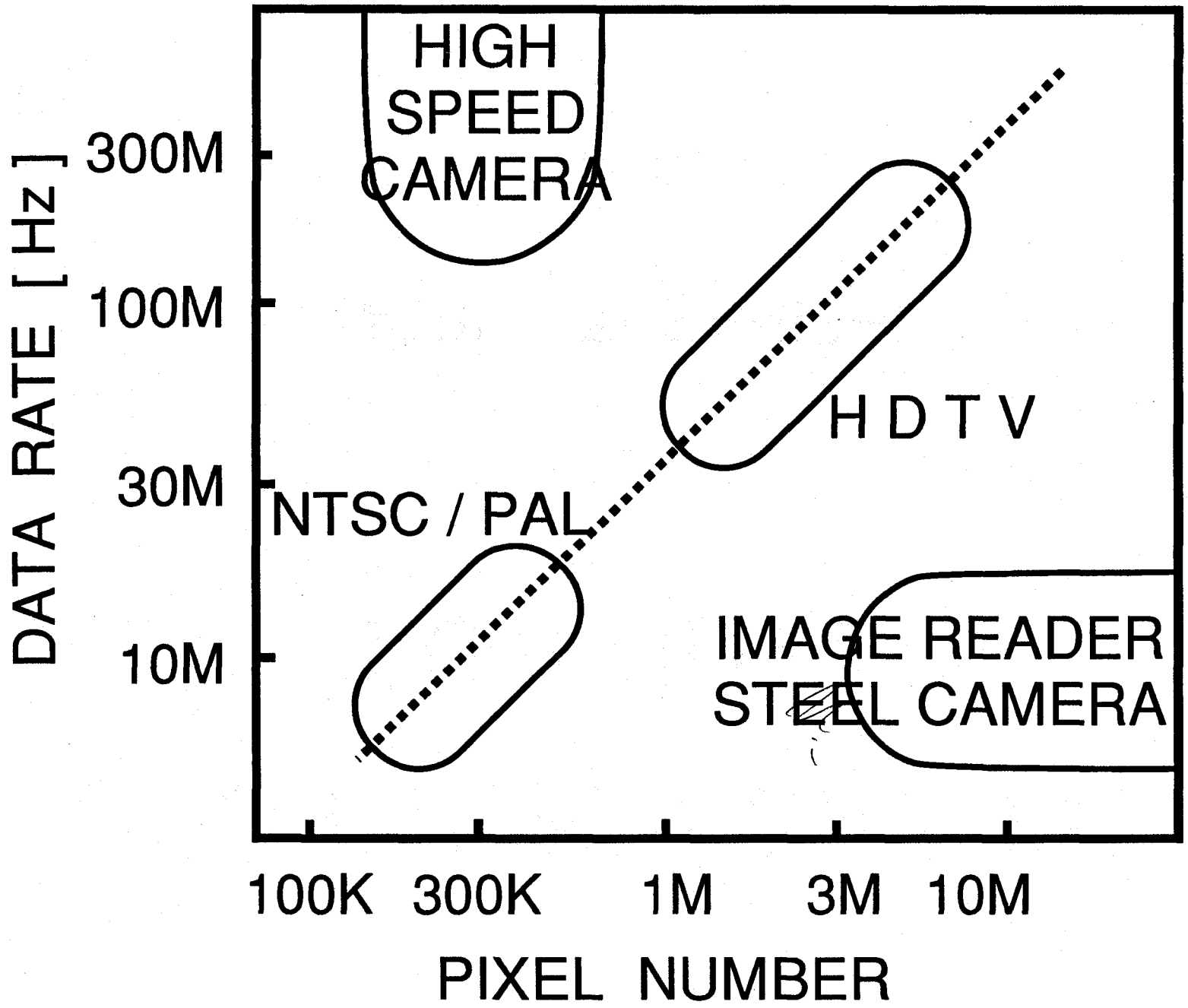
CCD IMAGE SENSORS FOR HDTV

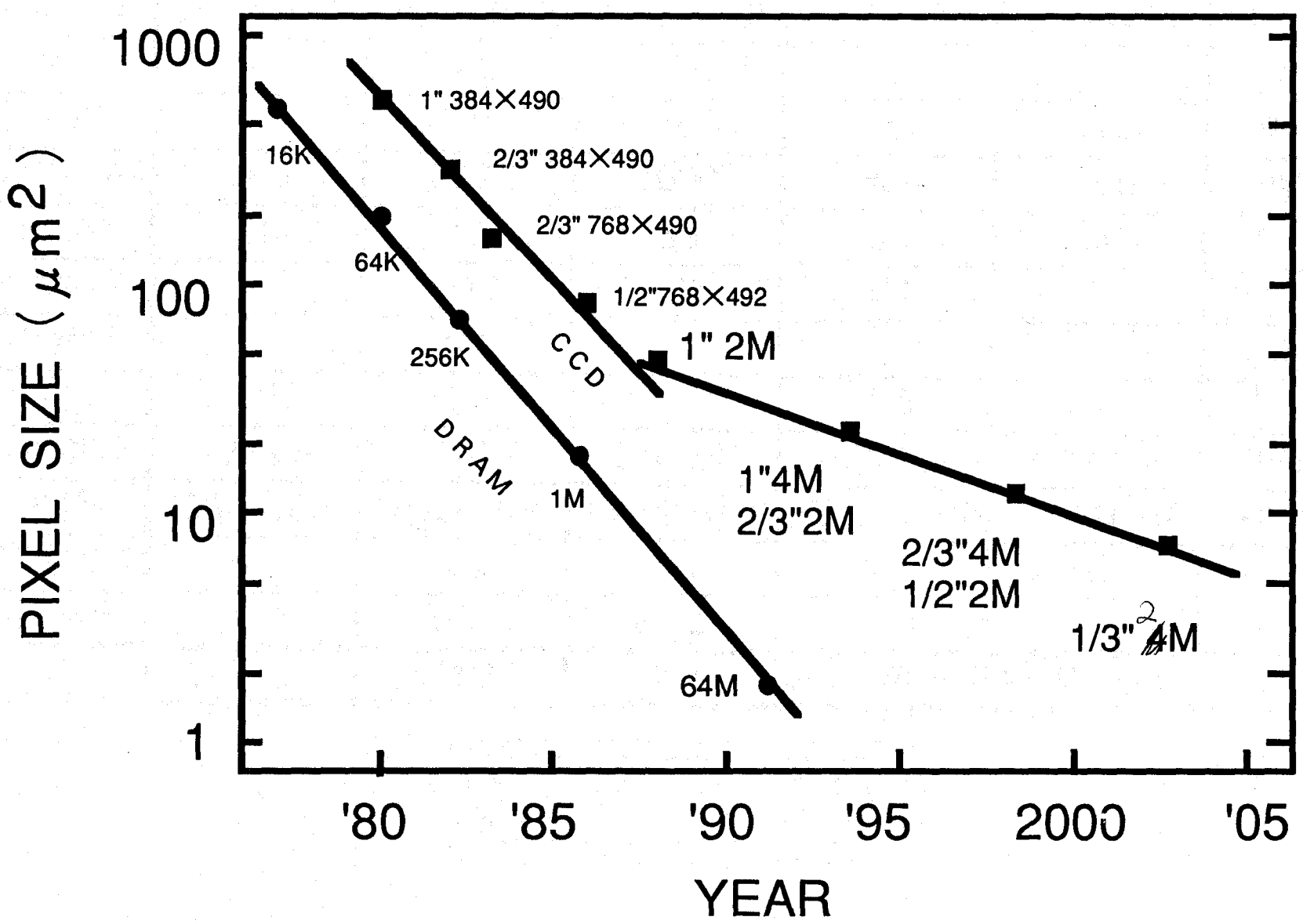
NOBU. TERANISHI

NEC Corporation

NEC

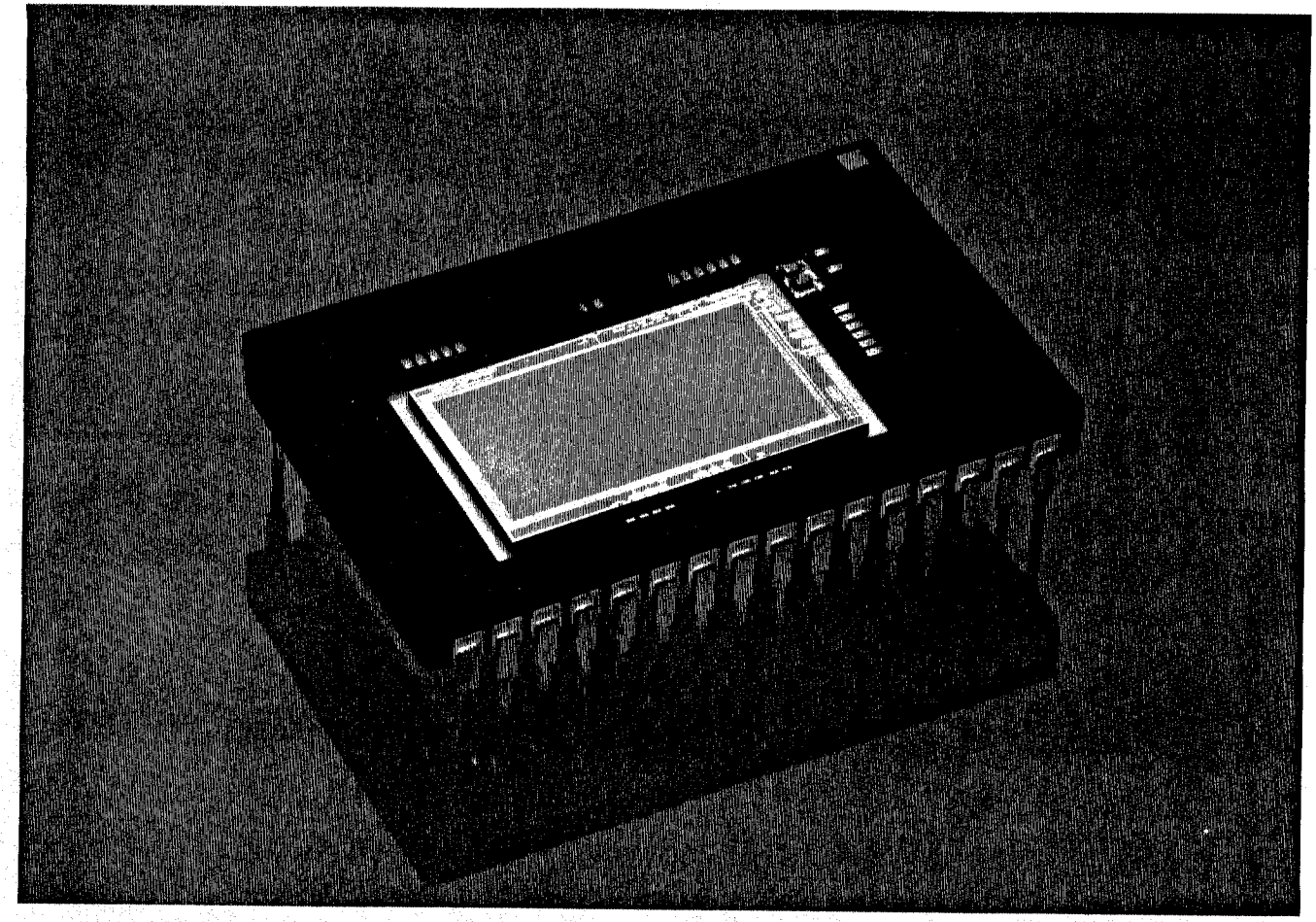

HIGH
SPEED
CAMERA
HDTV
NTSC / PAL
IMAGE READER
STEEL CAMERA
DATA RATE [Hz]
300M
100M
30M
10M
100K
300K
1M
3M
10M
PIXEL NUMBER

CCD TREND


1000
100
10
1
PIXEL SIZE (μm2)
'80
'85
'90
'95
2000
'05
YEAR
1" 384×490
2/3" 384×490
2/3" 768×490
1/2"768×492
1" 2M
CCD
16K
64K
256K
1M
64M
DRAM
1"4M
2/3"2M
2/3"4M
1/2"2M
1/3"4M

HDTV CCD

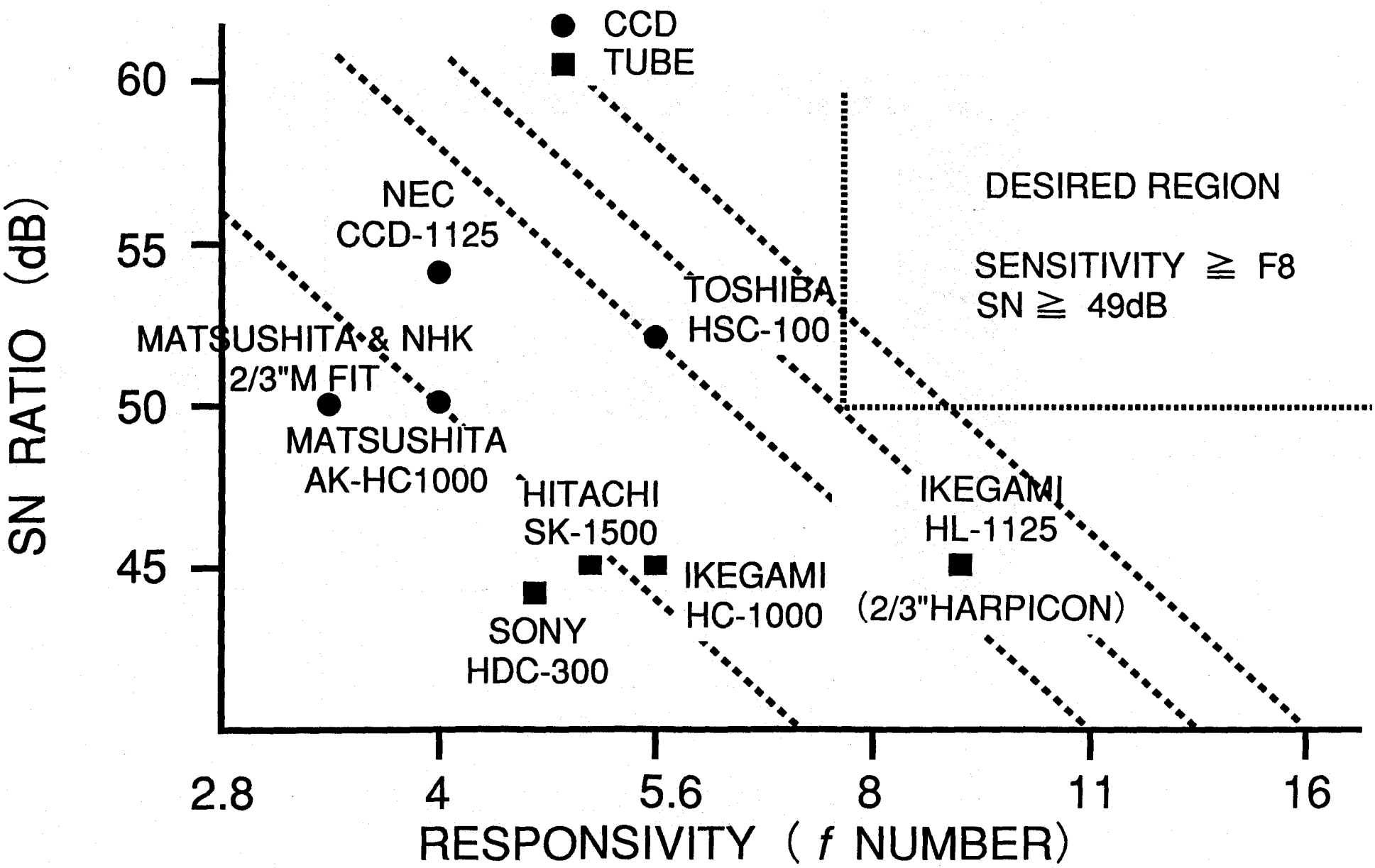
	NEC	Toshiba	Sony	Matsushita	Matsushita	
Scheme	IL	a-Si / IL	FIT	FIT	FIT	
Image Size	1 "	1 "	1 "	1 "	2/3 "	
Pixel No.	1920×1035	1920×1035	1920×1036	1258×1035	1258×1035	H×V
Pixel Size	7.3×7.6	7.3×7.6	7.3×7.6	10.8×7.4	7.6×5.2	μm^2
Rule	1.4	1.0		1.2	0.8	μm
Aperture		100				%
Sensitivity		210	75	50	24	nA / lx
D. Range	71	72	72	72	70	dB
Sat.Current	760	2000	1000	900	300	nA
Smear		-110	-100	-100	-100	dB
Lag		1.3	≤1		<1	%
Die Size	16.5×10.0	16.2×10.5	17.4×16.8	15.6×14.4	11.6×12.2	mm^2
Date	'88.2.	'88.2.	'90.2	'89.2.	'91.2.	
Camera	3CCD,1CCD	3CCD	3CCD	3CCD	3CCD	



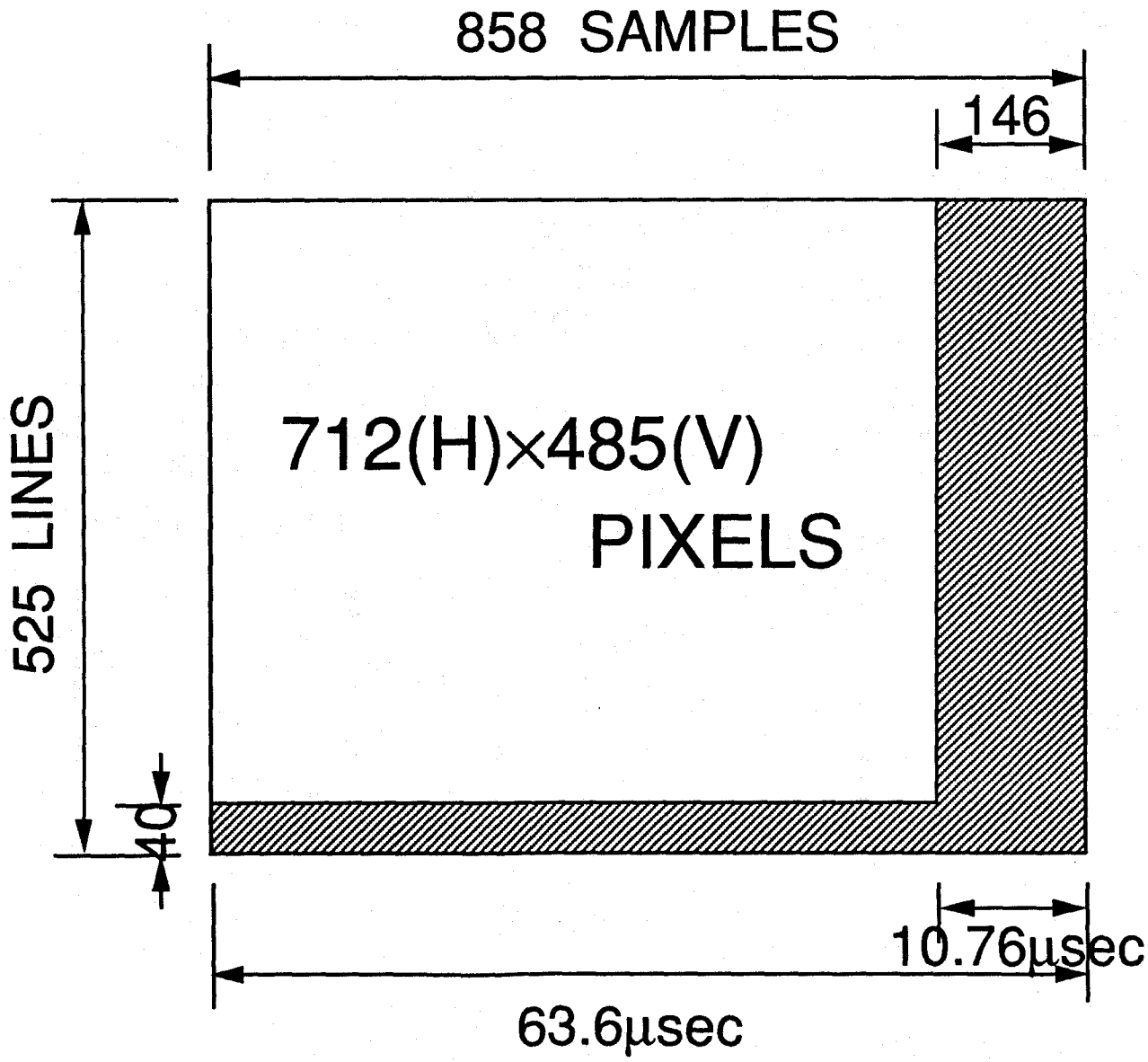
2M PIXEL IL CCD

NEU

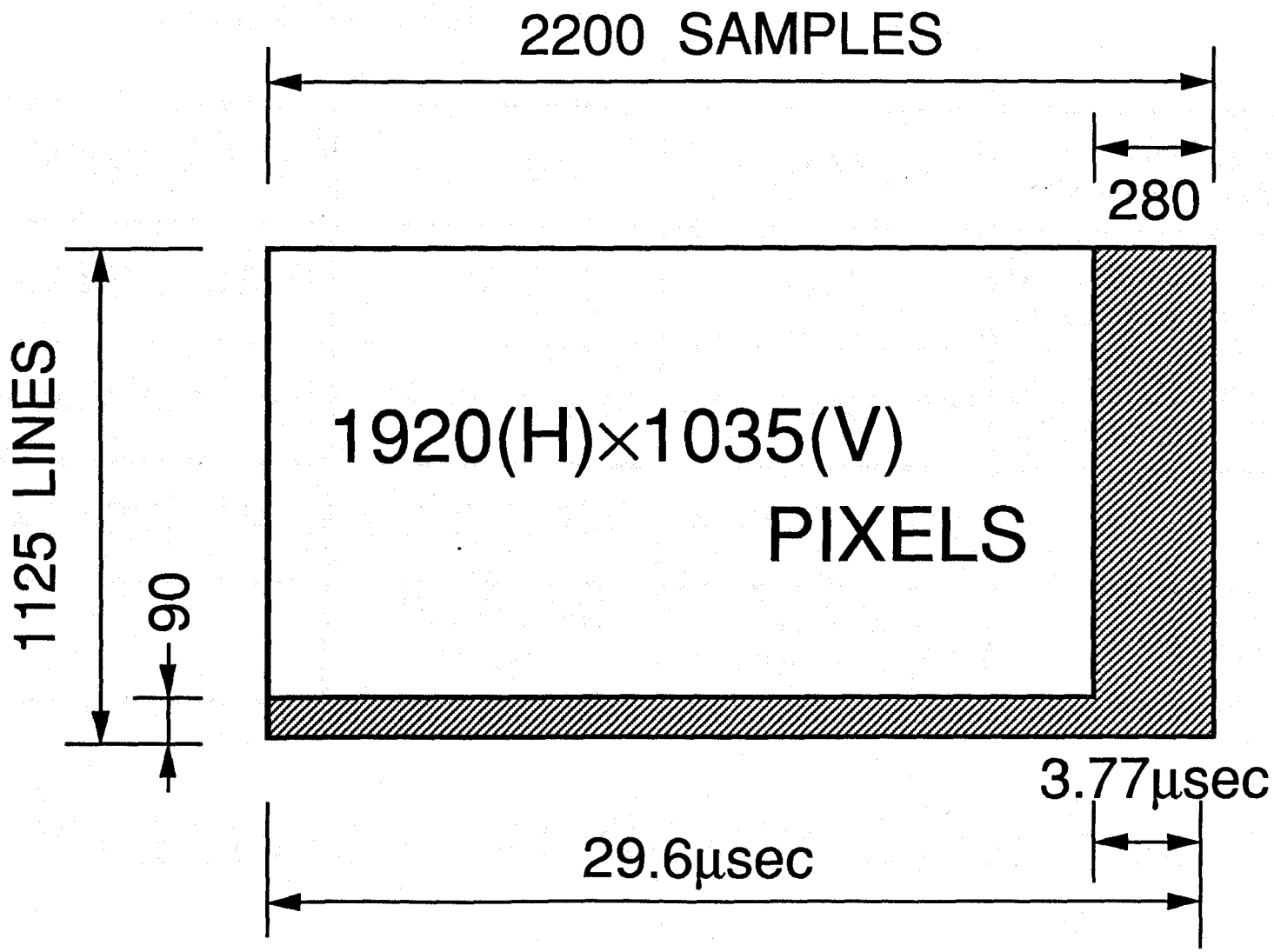
REPRODUCED PICTURE BY 2M PIXEL IL CCD


HDTV CAMERA COMPARISON
CCD
TUBE
60
55
50
45
SN RATIO (dB)
NEC
CCD-1125
TOSHIBA
HSC-100
MATSUSHITA & NHK
2/3"M FIT
MATSUSHITA
AK-HC1000
HITACHI
SK-1500
IKEGAMI
HC-1000
SONY
HDC-300
IKEGAMI
HL-1125
(2/3"HARPICON)
DESIRED REGION
SENSITIVITY ≧ F8
SN ≧ 49dB
2.8
4
5.6
8
11
16
RESPONSIVITY (f NUMBER)

NTSC FORMAT


858 SAMPLES
146
525 LINES
712(H)×485(V)
PIXELS
40
10.76µsec
63.6µsec

HIVISION FORMAT



~7½ µm pixel

COMPARISON BETWEEN NTSC AND HIVISION

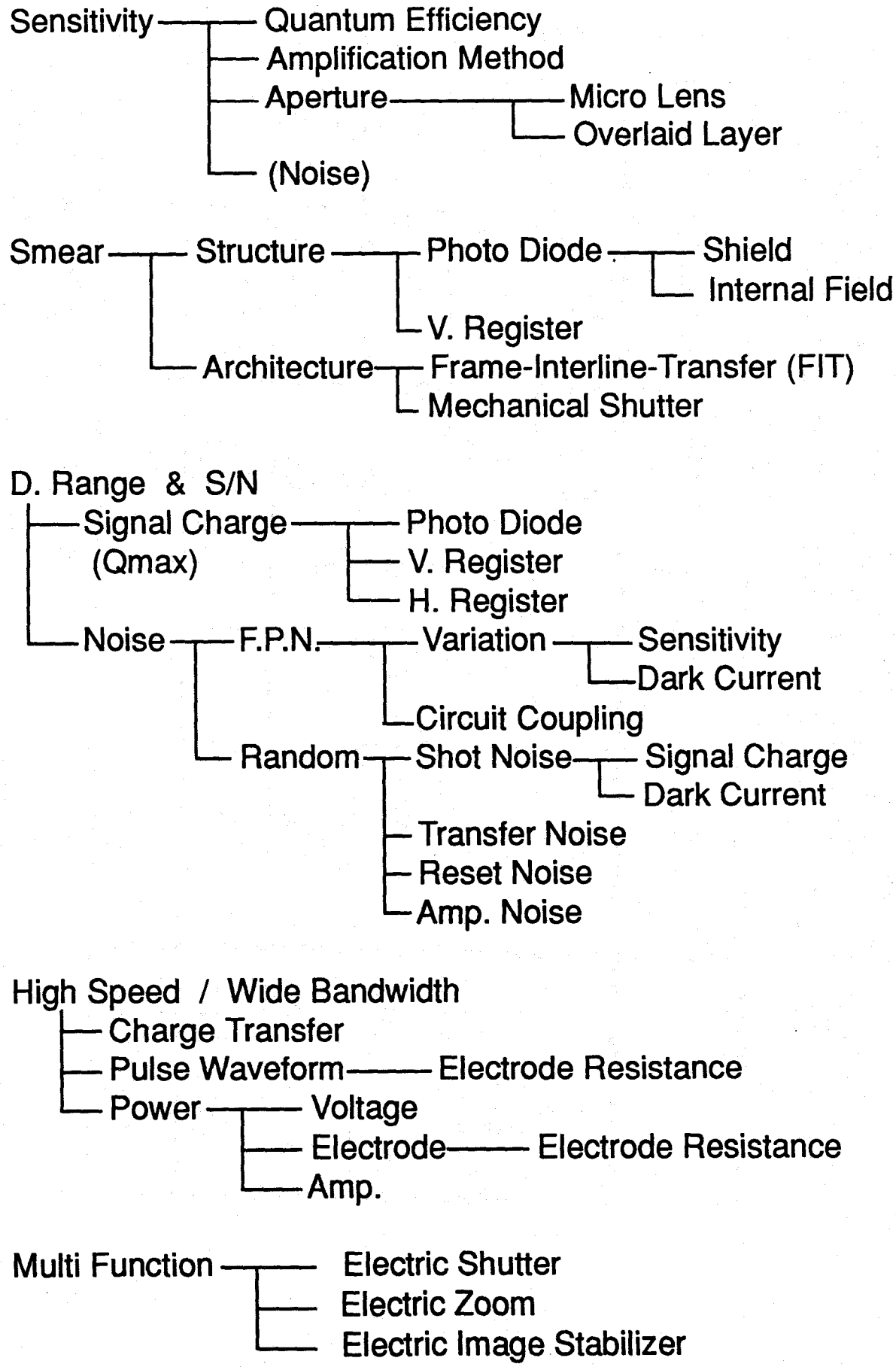
	NTSC (1/3",0.36M)	HIVISION (1",2M)	PROBLEM
PIXEL SIZE (μm)	6.8(H)×7.5(V)	7.3(H)×7.6(V)	
IMAGE AREA (mm)	4.8(H)×3.6(V)	14.0(H)×7.8(V)	SHADING BY MICROLENS PULSE DECAY
DATA RATE (MHz)	13.5	74.5	TRANSFER EFFICIENCY BANDWIDTH OF AMP.
H-BLANKING (μsec)	10.76	3.77	2CH-HCCD TRANSFER VOD SHUTTER

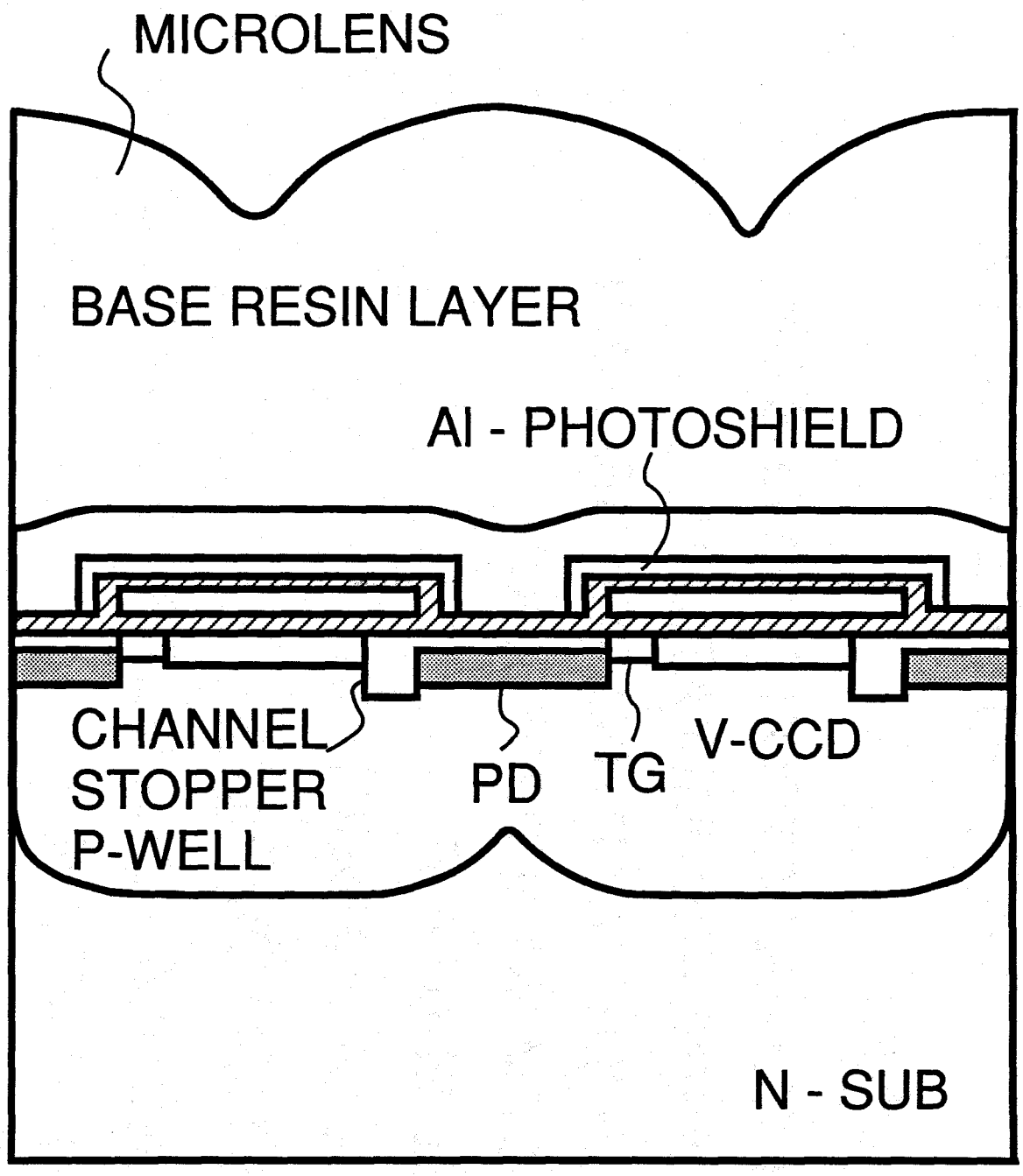
COMMON PROBLEM

- HANDLING CAPABILITY OF VCCD
- SENSITIVITY
- SMEAR

IMAGER SCHEME COMPARISON

	Sensitivity	S / N	D / R	Smear	L a g
I L	△	○	○	×	○
FT (Rear Illumination)	○	○	○	△	○
FIT+Lens	○	○	○	○	○
C S D	△	○	◎	×	○
Overlaid	○	○	○	○	×
Amplified	◎	?	?	○	○
M O S	△	△	○	○	○
H A R P	◎	○	◎	◎	×


Sensitivity
Quantum Efficiency
Amplification Method
Aperture
Micro Lens
Overlaid Layer
(Noise)
Smear
Structure
Photo Diode
Shield
Internal Field
V. Register
Architecture
Frame-Interline-Transfer (FIT)
Mechanical Shutter
D. Range & S/N
Signal Charge
(Qmax)
Photo Diode
V. Register
H. Register
Noise
F.P.N.
Variation
Sensitivity
Dark Current
Circuit Coupling
Random
Shot Noise
Signal Charge
Dark Current
Transfer Noise
Reset Noise
Amp. Noise
High Speed / Wide Bandwidth
Charge Transfer
Pulse Waveform
Electrode Resistance
Power
Voltage
Electrode
Electrode Resistance
Amp.
Multi Function
Electric Shutter
Electric Zoom
Electric Image Stabilizer



CROSS - SECTIONAL VIEW OF PIXEL

PHOTODIODE DESIGN

FUNCTIONS

- PHOTO - ELECTRON CONVERSION
- CHARGE ACCUMULATION
- COMPLETELY DEPLETED READOUT
- BLOOMING SUPPRESSION
- VOD SHUTTER
- SMEAR REDUCTION

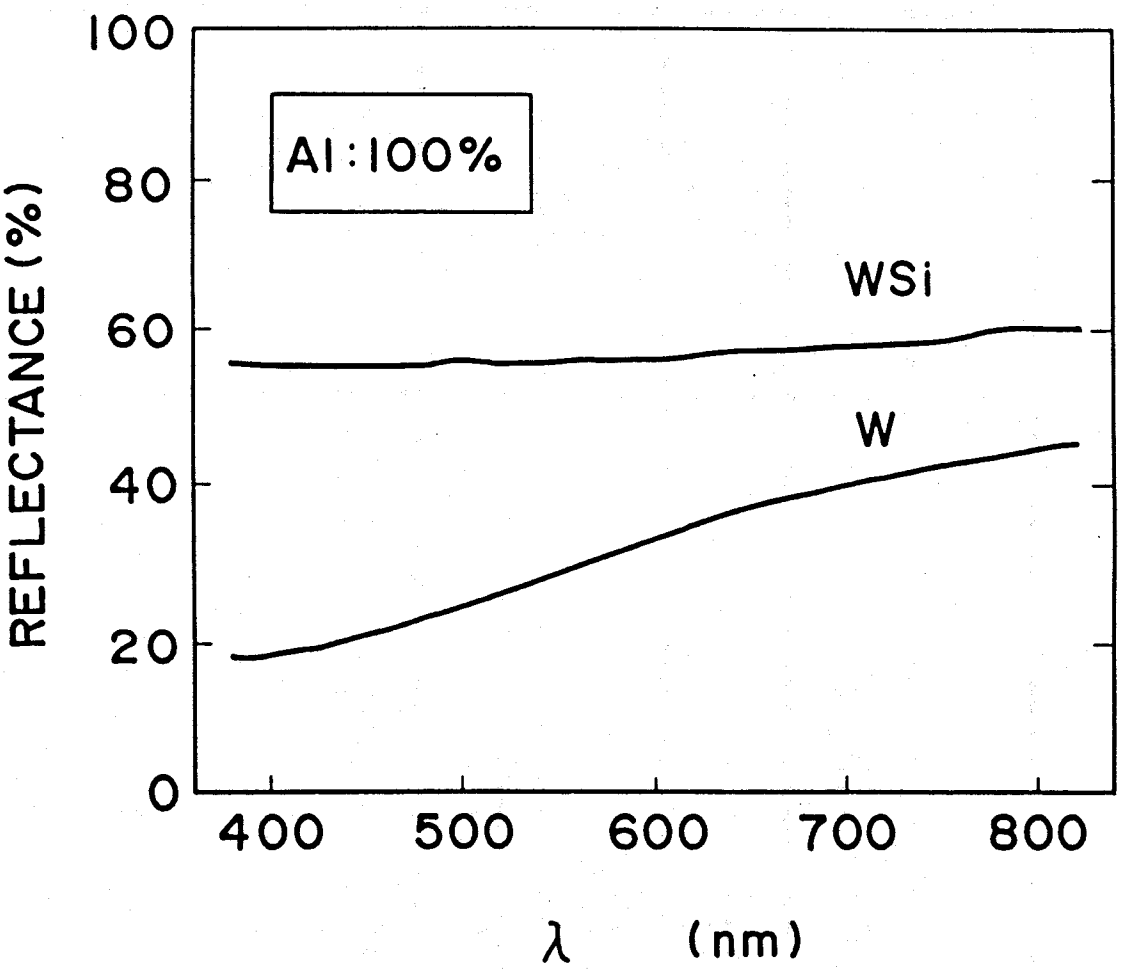
SIMULATION DIFFICULTY

- FUNCTIONS CAN NOT BE SEPARATELY SIMULATED.
- 3 - DIMENSION
- LARGE MESH NUMBER

PHOTO SHIELD MATERIAL

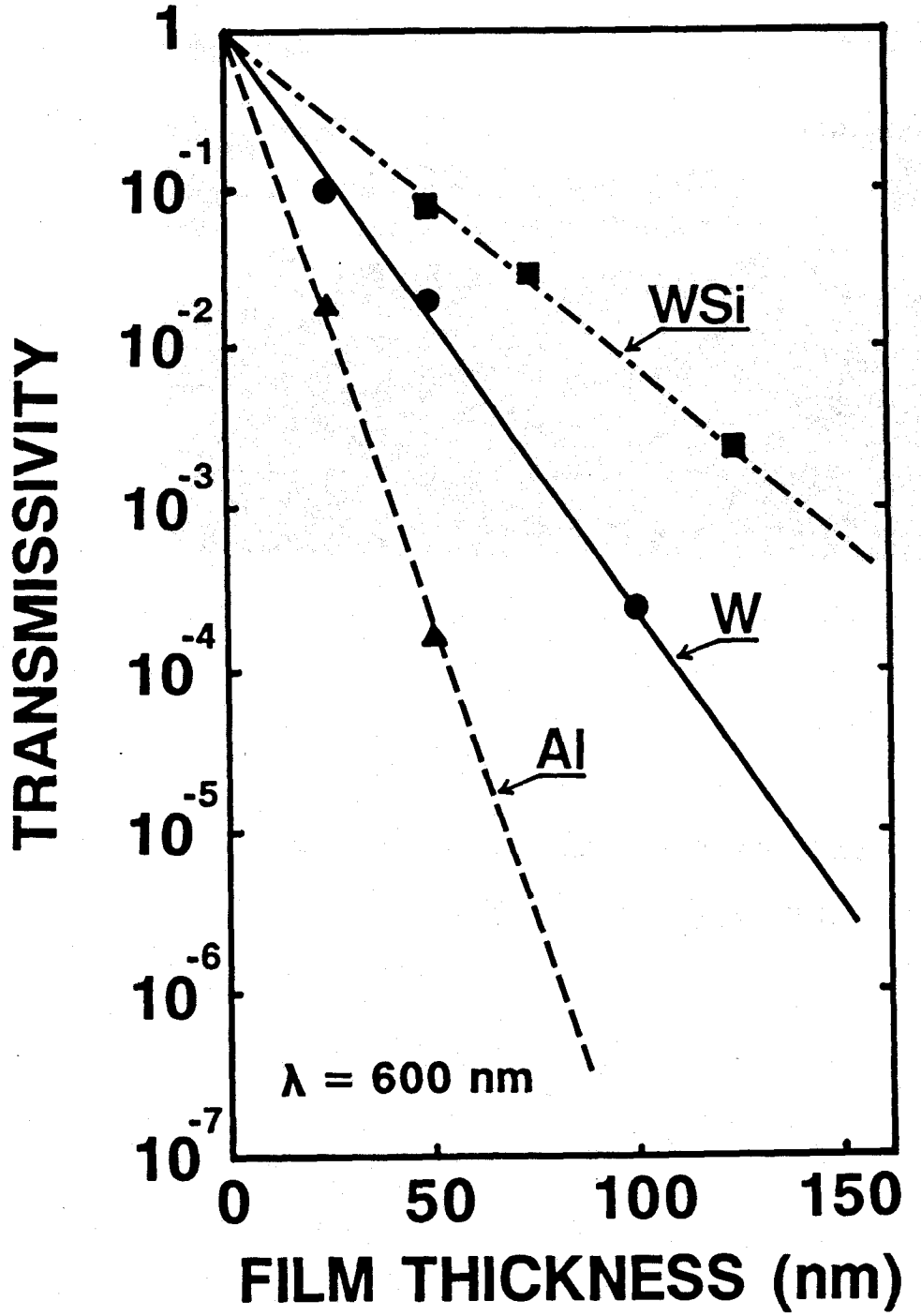
	W	Al
TRANSMITTANCE		○
PIN HOLE	○	
COVERAGE	○	
REFLECTIVITY	○	
APERTURE UNIFORMITY		
GRAIN GROWTH	○	
STRESS MIGRATION	○	

REFLECTANCE OF W AND WSi

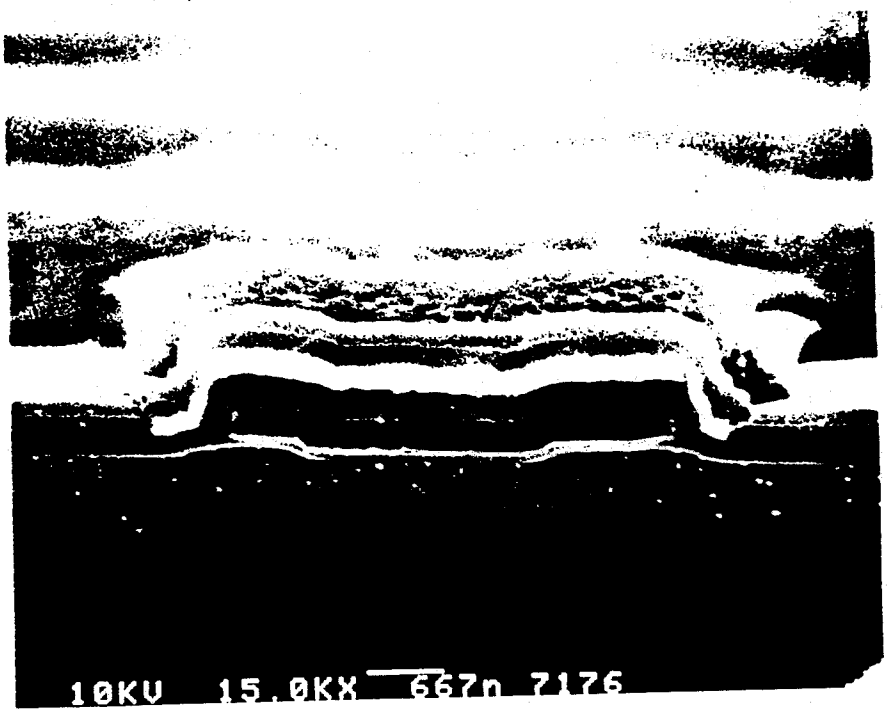


by A. TOYODA et al (1990)

TRANSMISSIVITY OF PHOTOSMIELD MATERIAL

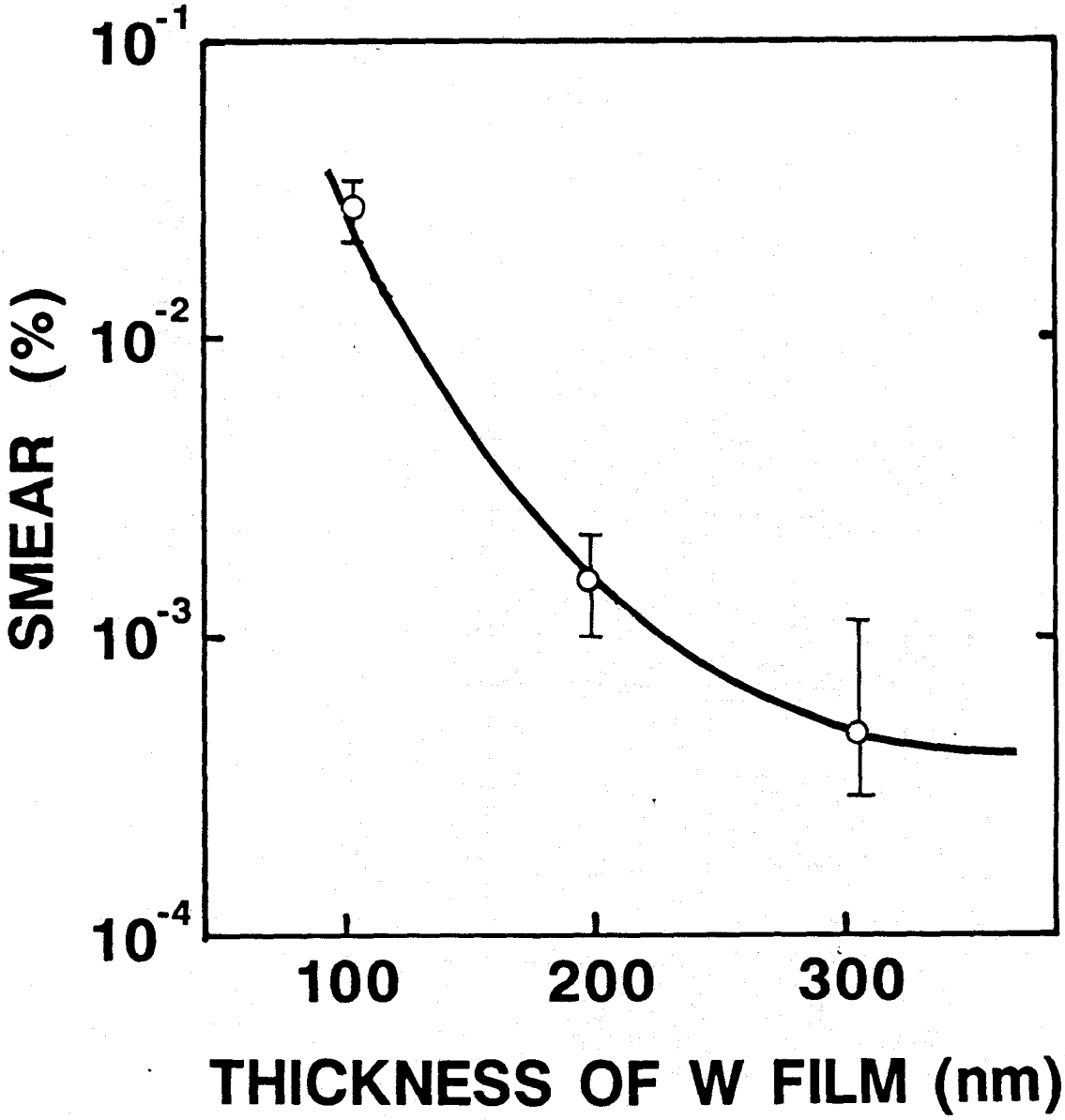


by A. TOYODA et al (1990)



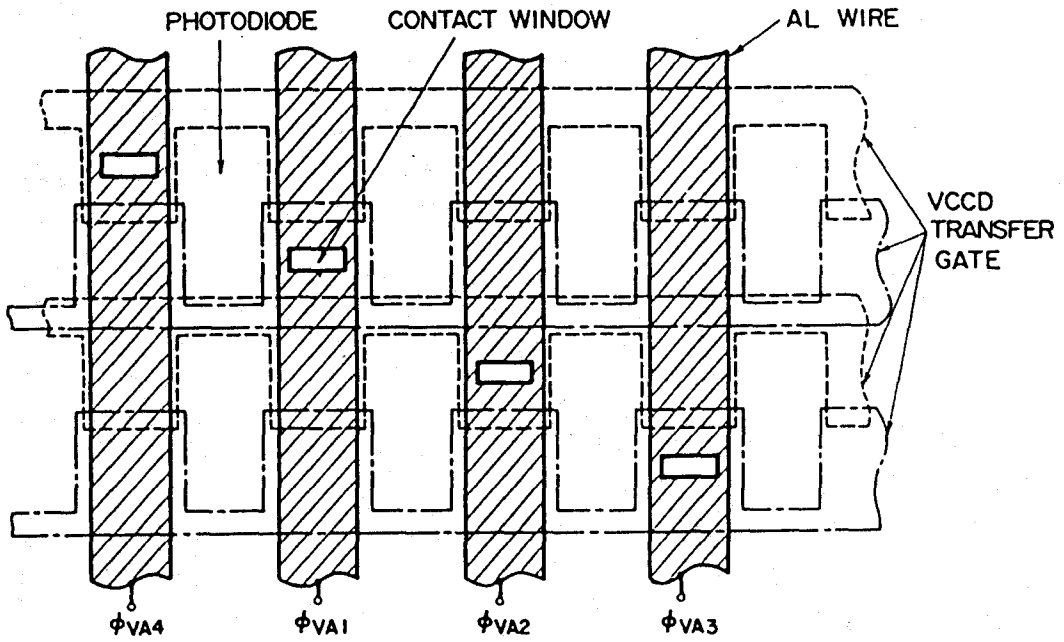
An SEM photograph of a CCD pixel cross-section.

SMEAR vs. W THICKNESS



by A. TOYODA et al (1990)

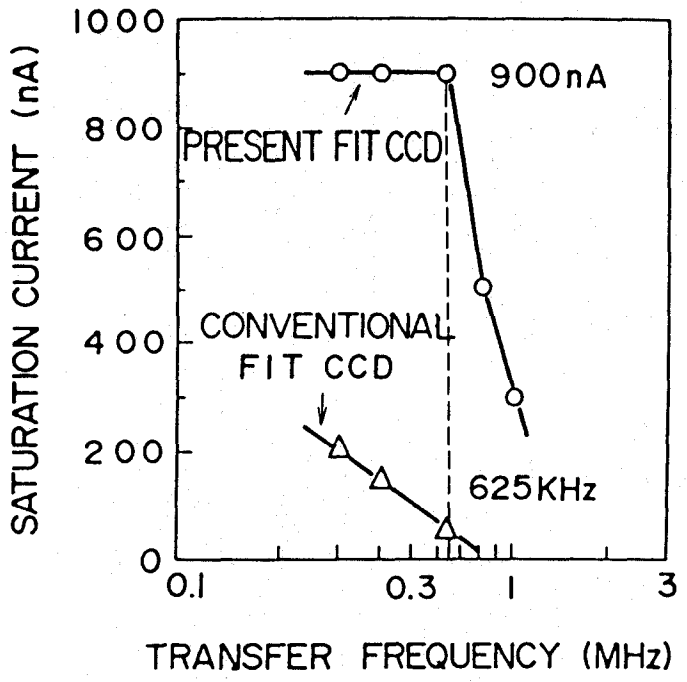
Al SHUNT STRUCTURE



Poly-Si/AL double layer transfer gate

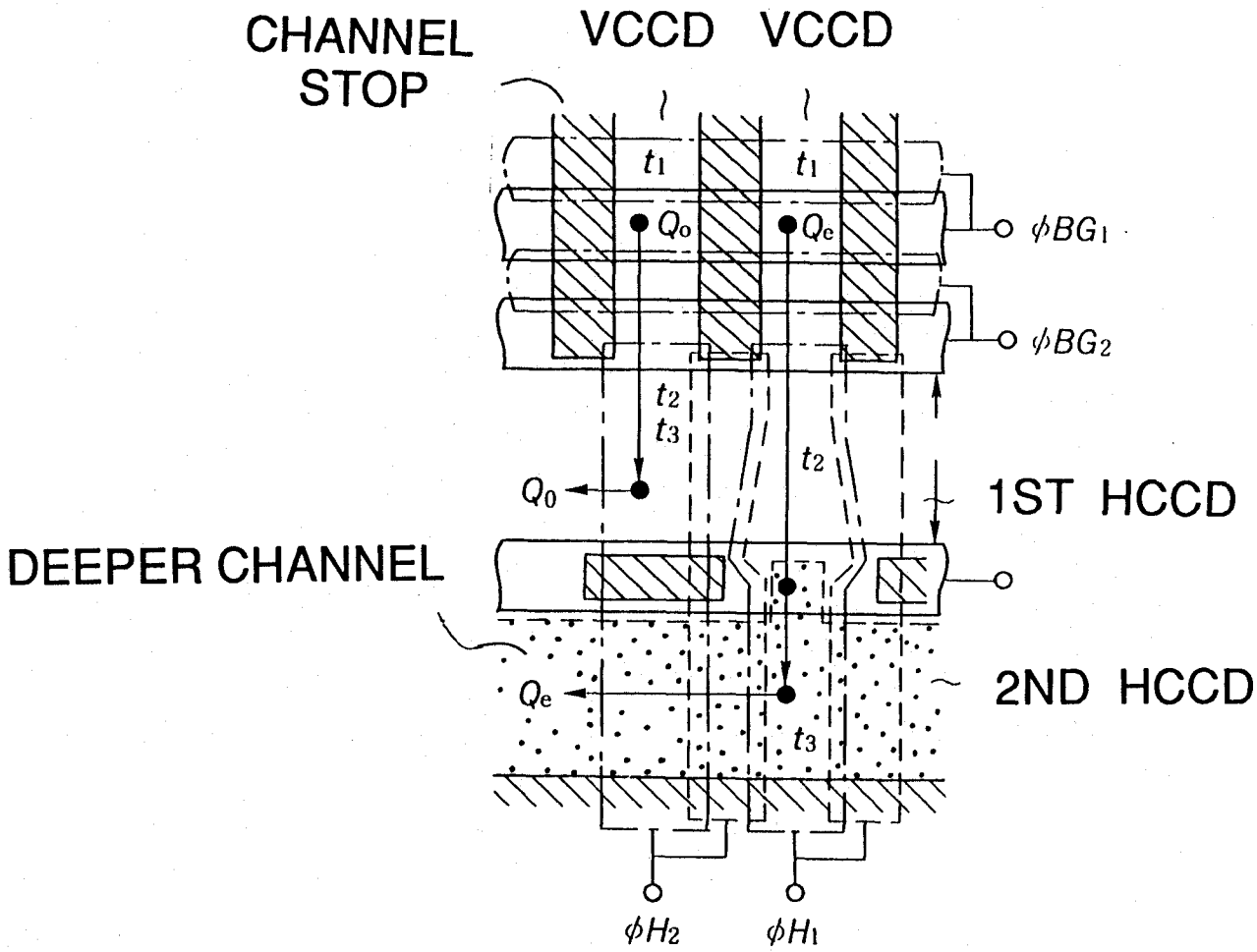
by T.Nobusada et al (1989)

EFFECT BY Al SHUNT STRUCTURE



by T.Nobusada et al (1989)

2CH - HCCD STRUCTURE



by S. MANABE (1990)

OUTPUT NOISE REDUCTION

COMPONENT

- RESET NOISE
- AMP. NOISE

METHOD

- SMALL C_{FJ}
- NOISE REDUCTION CIRCUIT
- NEW OUTPUT ARCHITECTURE

NOISE REDUCTION CIRCUIT

1. CORRELATED DOUBLE SAMPLING (CDS)
   M.H.WHITE et al (1974).

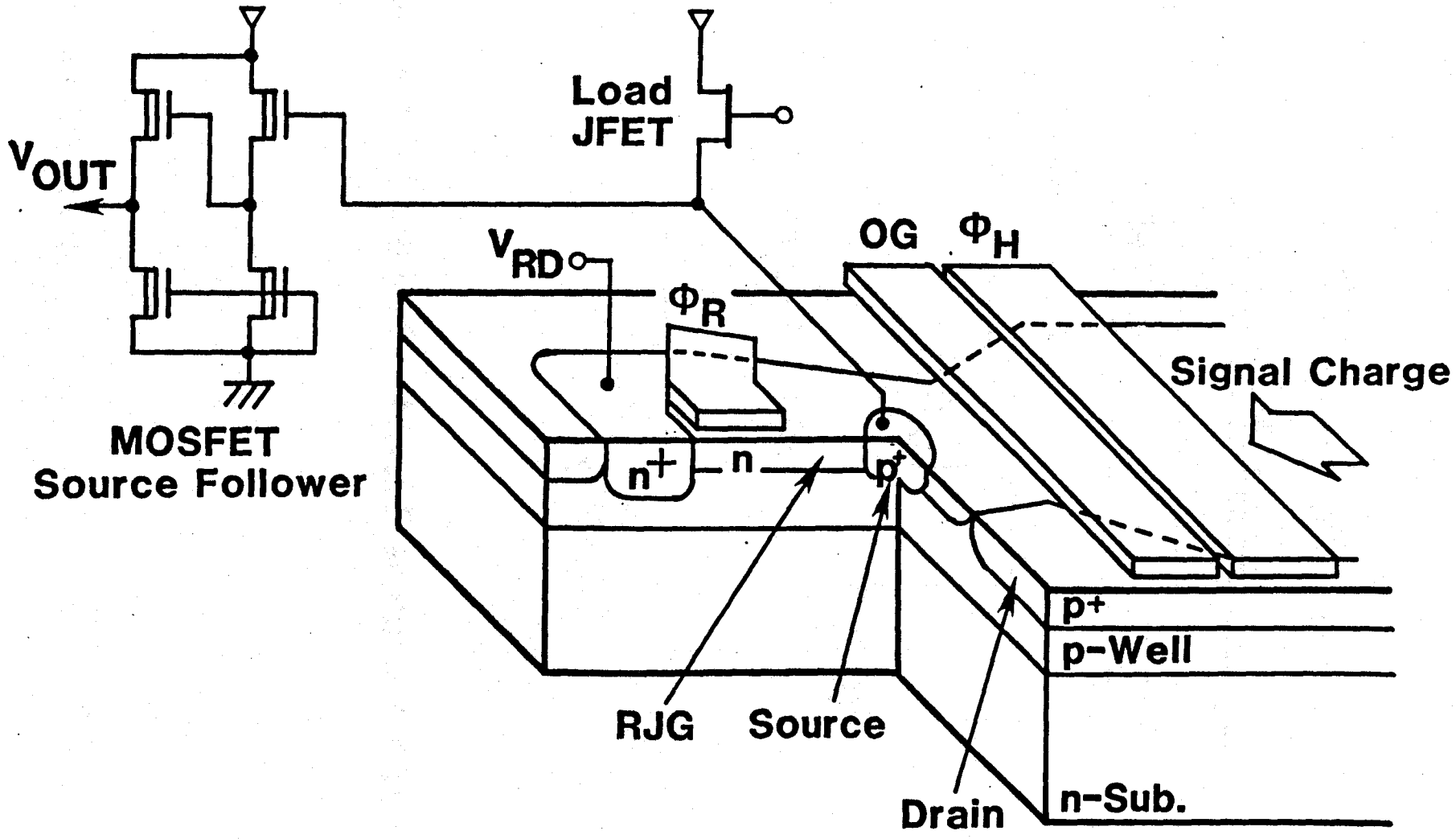
2. DIFFERENTIATION WITH SAMPLING
   P.A.LEVINE (1985).

3. INVERSE ADDITION METHOD
   Y.ENDO et al (1985).

4. DELAYED AND DIFFERENTIAL NOISE SUPPRESSION (DDS)
   Y.NISHIDA et al (1985).

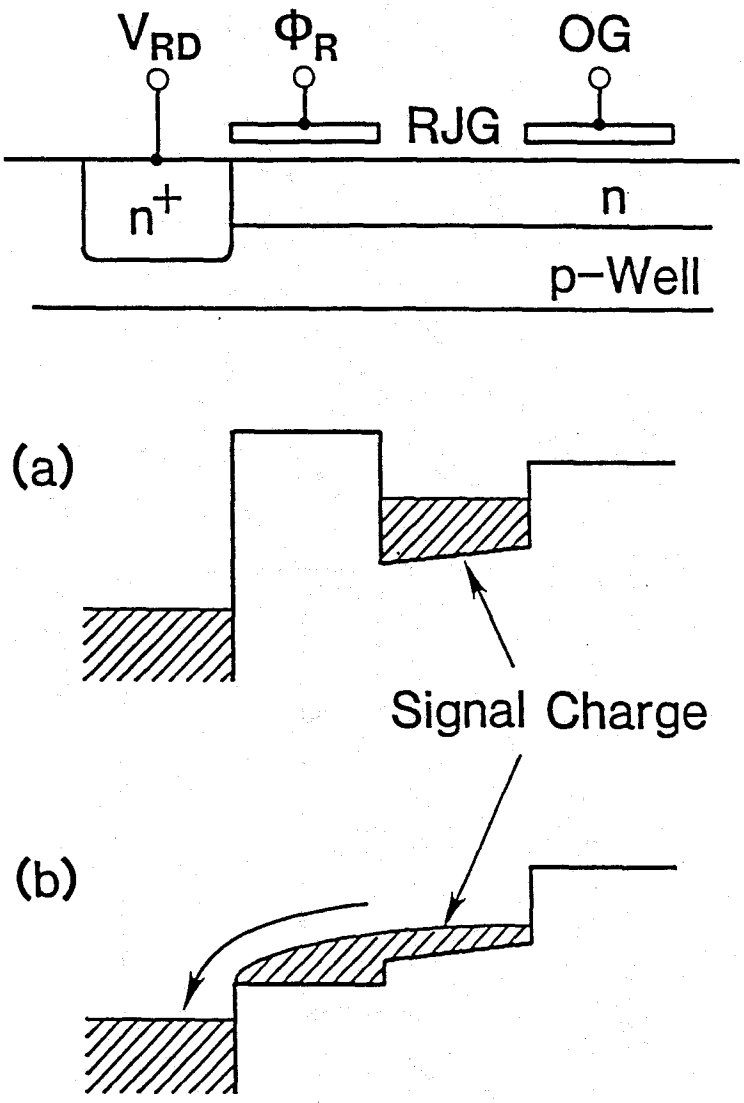
5. INTEGRAL DELAYED AND DIFFERENTIAL NOISE SUPPRESSION (IDDS)
   M.OHBO et al (1988).

6. REFLECTION DELAYING NOISE SUPPRESSION (RDS)
   M.OHBO et al (1989).



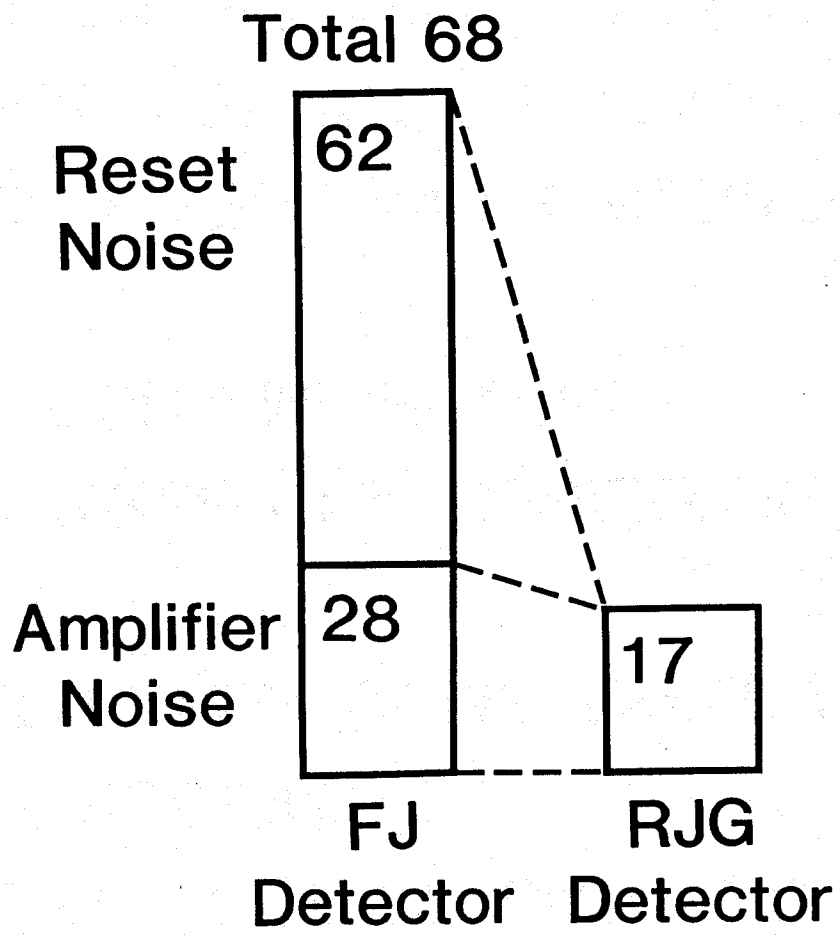
Ring-Junction-Gate Detector

by N. MUTOH et al (1989)



Complete Charge Transfer in Reset Operation

by N. MUTOH et al (1989)



Noise Equivalent Electrons

by N. MUTOH et al (1989)

CONCLUSIONS

1. DEVELOPMENT OF CCD FOR HDTV :
   JUST BEGINNING.
   USEFUL FOR SOME APPLICATIONS.

2. 1" 2M PIXEL (1ST GENERATION) :
   · FIT CCD + MICROLENS

3. 2/3" 2M PIXEL (2ND GENERATION) :
   · NOISE REDUCTION AT OUTPUT
   · SOMETHING NEW ON VCCD
   · ?