

What you see is what you get !?

Prof. dr. ir. Albert J.P. THEUWISSEN

Philips Semiconductors Image Sensors, Eindhoven (NL)
Technical University, Delft (NL)

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Outline

- Introduction : Figure of Merit
- Dynamic Range
- Number of Pixels
- Summary
- Conclusion

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Introduction

Figure of Merit (FoM)⁽¹⁾ =
 $\log_2(\text{dynamic range}) +$
 $\log_2(\text{total number of pixels})$
(information content a sensor can deliver)
dynamic range \neq true linear dynamic range
total number of pixels \neq effective number of
pixels

⁽¹⁾ see : T.Noguchi, Fuji Photo Film, PICS Conf. 1998.

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What you see is what you get !?

What you see in the leaflets or in the brochures, is that what you really get out of the sensor ?

Answer : not always !

Example : dynamic range

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True linear dynamic range (1)

$$= \frac{\text{(linear output swing)}}{\text{(total amount of noise)}}$$

linear output swing = maximum linear
charge content - dark current

total amount of noise = amplifier noise
+ dark current noise

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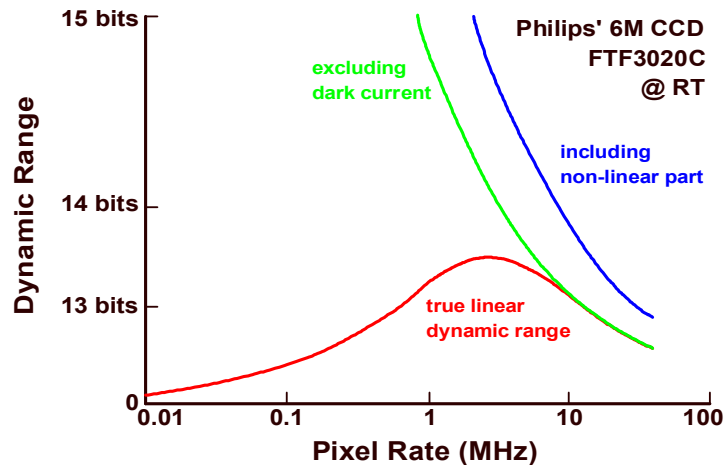
True linear dynamic range (2)

- some competitors include the non-linear part of the output swing !
- some competitors do not specify the temperature !
- all competitors do exclude the dark current !

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True linear dynamic range (3)



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What you see is what you get !?

What the pixels see, is that what you get
on the monitor or on the hard copy ?

Answer : not always !

Reasons : transport inefficiency, electrical
and optical cross-talk, non-ideal color
filter characteristics

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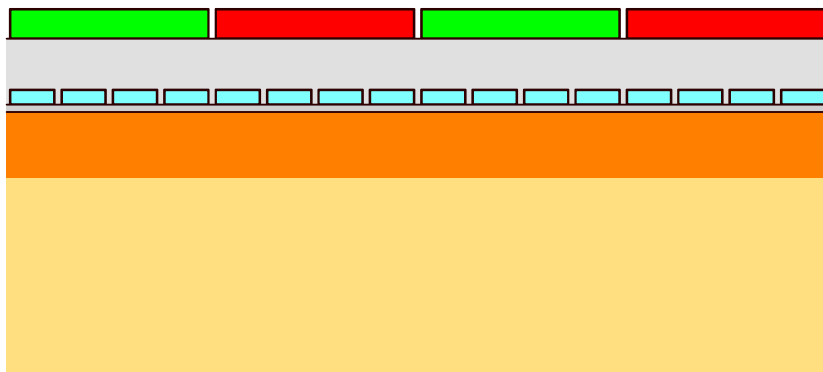
Transport efficiency (1)



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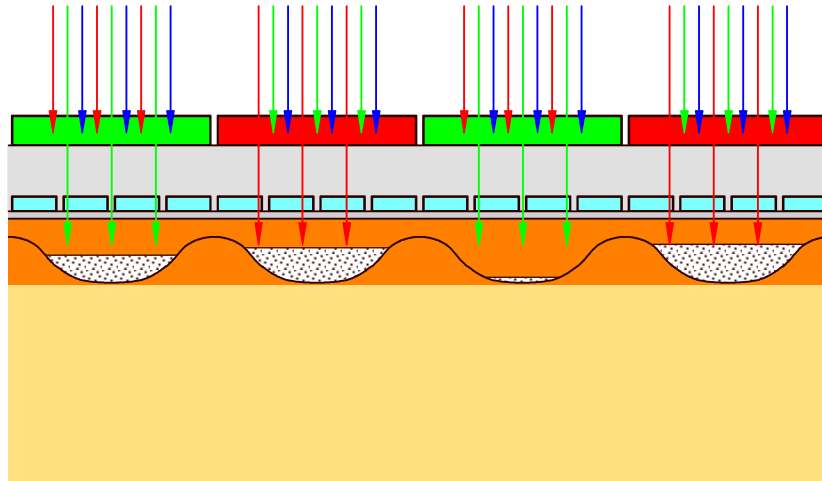
Transport efficiency (1)



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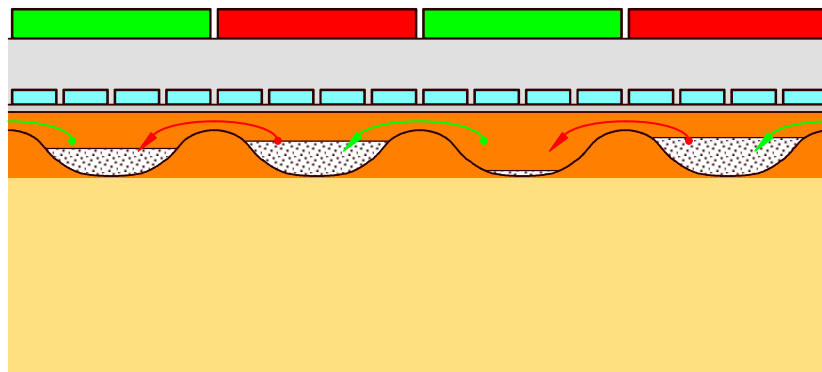
Transport efficiency (1)



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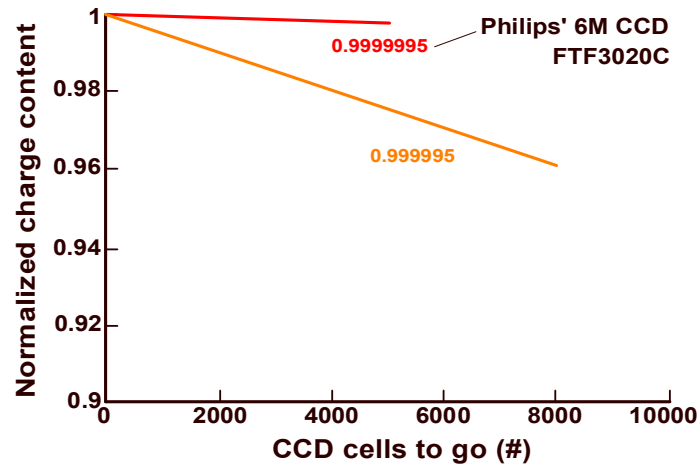
Transport efficiency (1)



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Transport efficiency (2)



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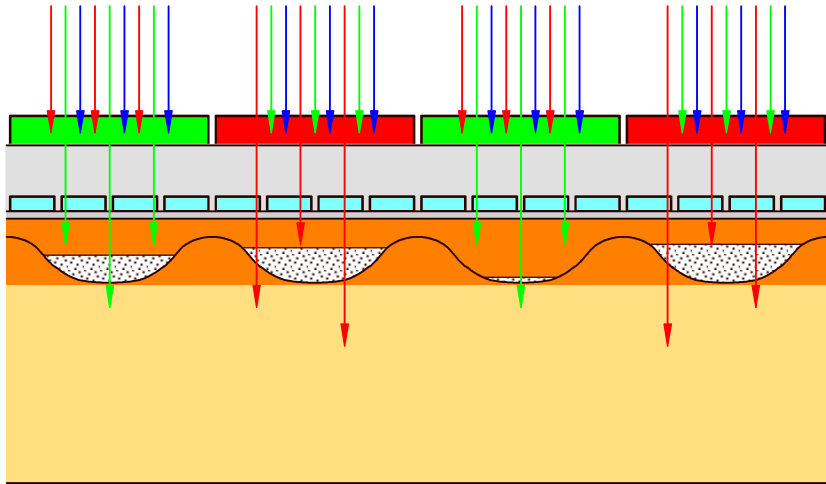
Transport efficiency (3)

- transport inefficiency unsharpens the image (B/W) or mixes colors,
- transport inefficiency effects are NOT correctable !
- optimised technology, optimised lay-out + design : 4 phase transport.

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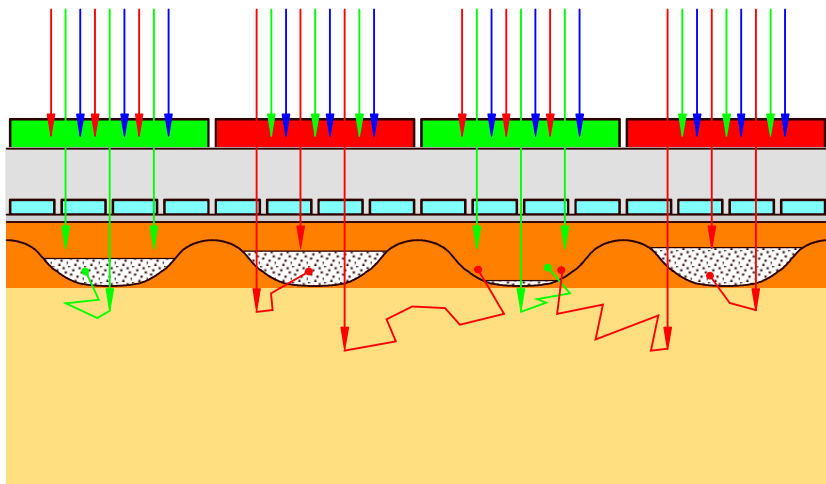
Electrical cross talk (1)



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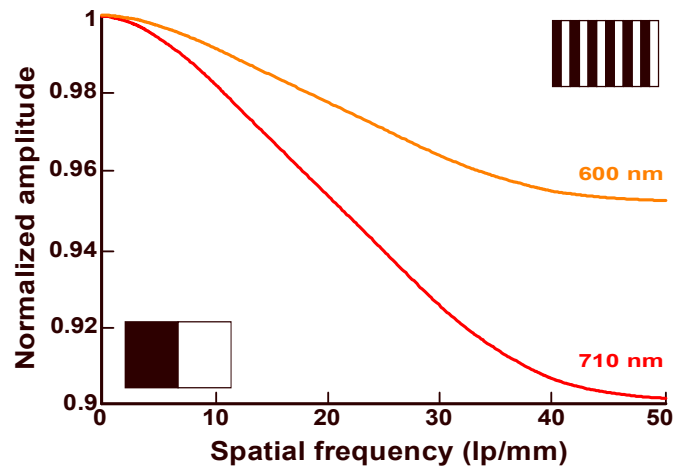
Electrical cross talk (1)



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Electrical cross talk (2)



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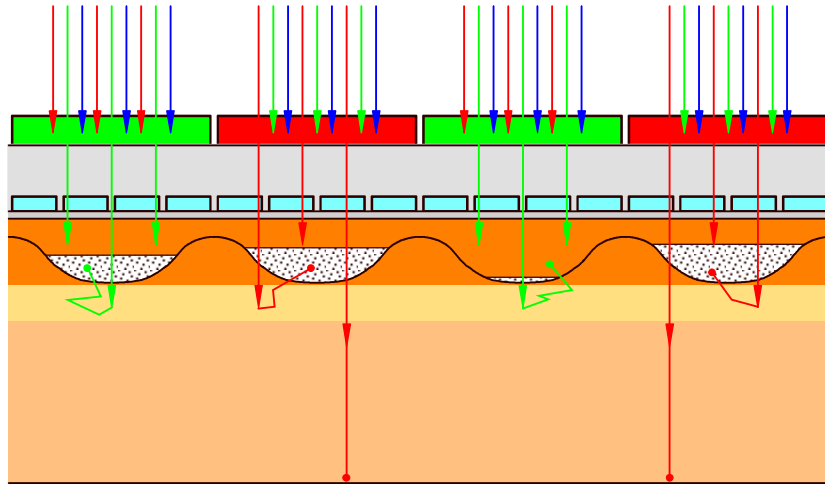
Electrical cross talk (3)

- optimised lay-out + design : vertical anti-blooming (VAB),
- VAB acts as :
 - internal IR filter,
 - dark current reducer,
 - eye curve matcher.

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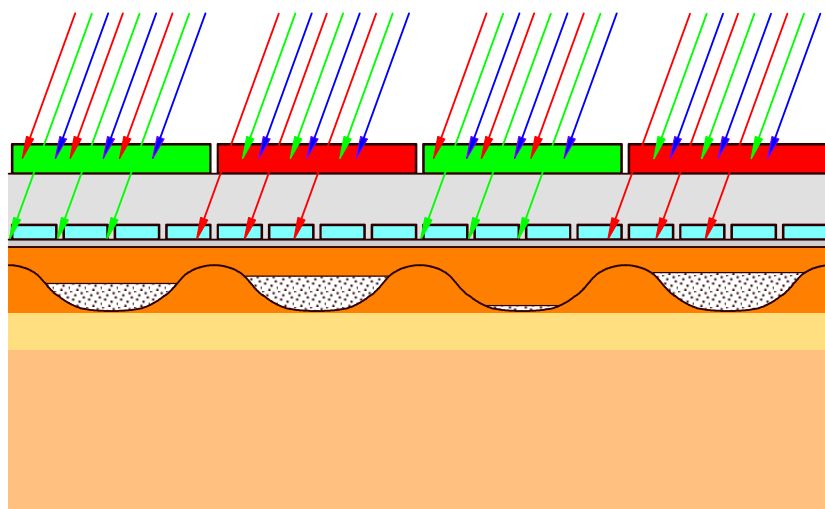
Effect of VAB in Philips' 6M CCD



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Optical cross talk (1)



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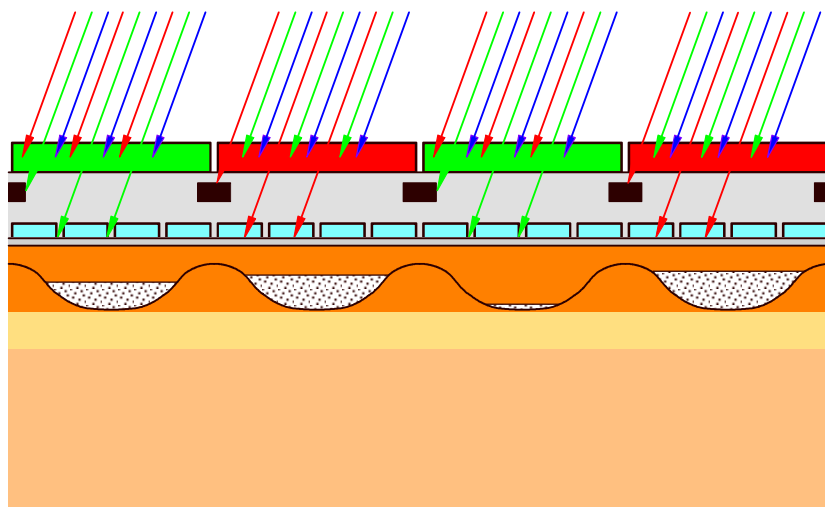
Optical cross talk (2)

- depends strongly on F number !
- introduction of an optical grid.

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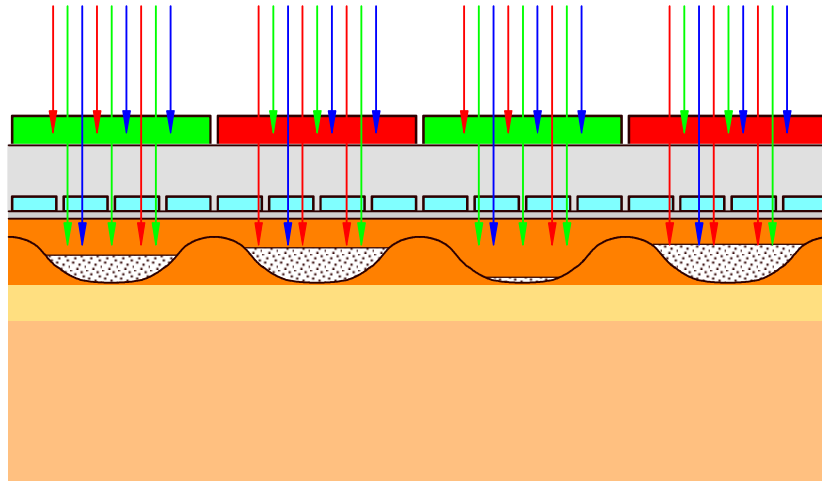
Optical grid in Philips' 6M CCD



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Color filter characteristics (1)



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Color filter characteristics (2)

- cross color effects are correctable,
- S/N loss (up to 3 dB),
- optimise filter characteristics.

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Summary (1)

True linear dynamic range \neq
dynamic range,

In the calculation of dynamic range, the
effect of dark current (noise) needs to
be included !

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Summary (2)

Effective number of pixels \neq
total number of pixels,

Philips' 6M CCD comes pretty close :

- very high transport efficiency (4 phase),
- internal IR cut-off filter to reduce electrical cross talk,
- optical grid to reduce optical cross talk,
- optimized filter technology for color rendering.

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Conclusion

$$\text{F.o.M. (FTF3020C)} = 14 + 22.58 = 36.58$$

Challenge everybody to do this exercise
with every competing sensor !