

# Computer Science E-7

## Exposing Digital Photography

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Lecture 10: Digital Cameras (cont.)  
November 16, 2009

[danallan@mit.edu](mailto:danallan@mit.edu)

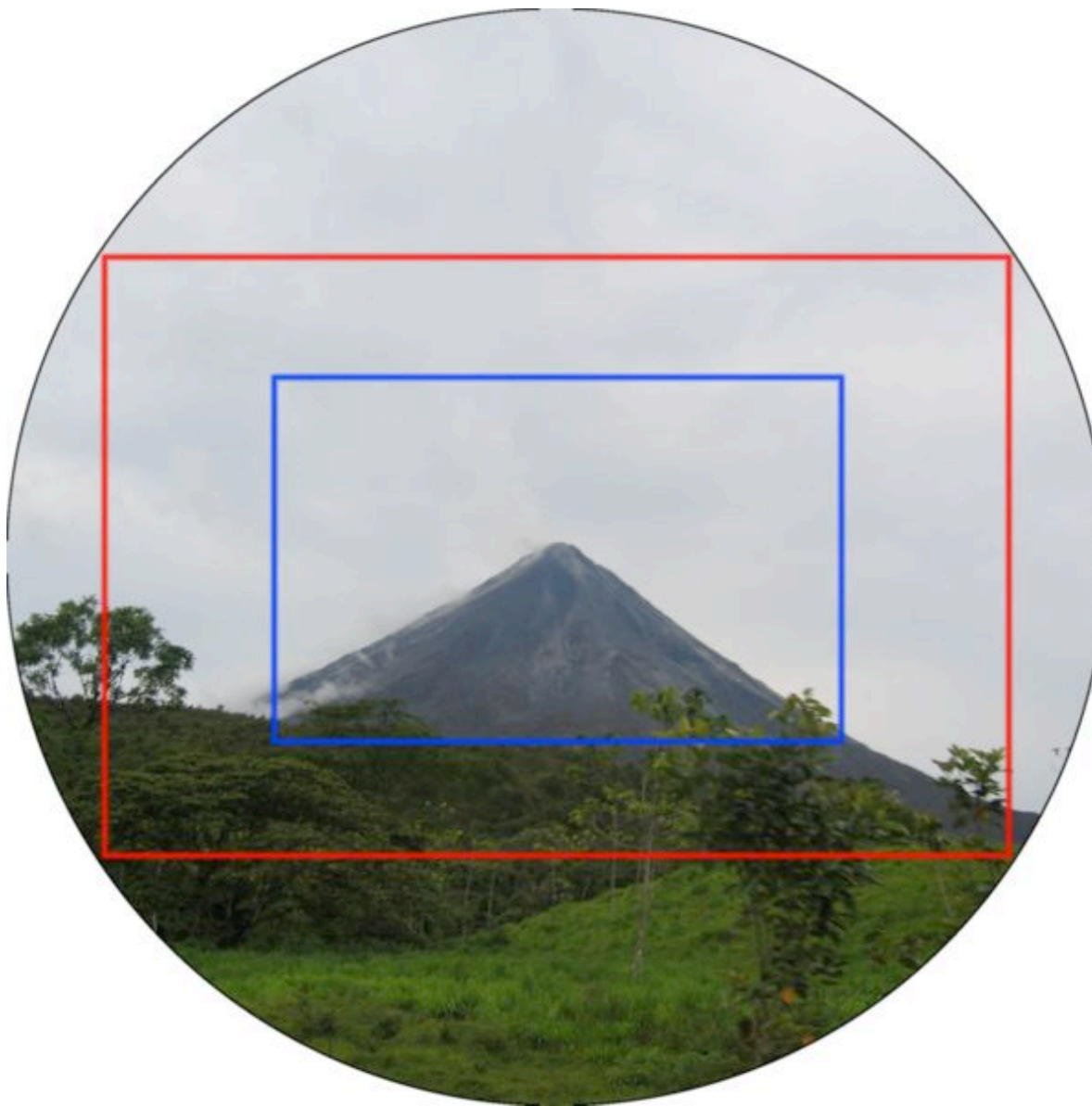
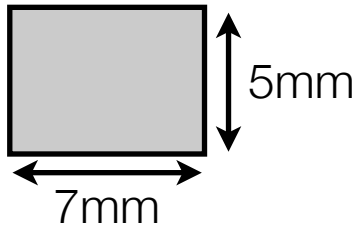


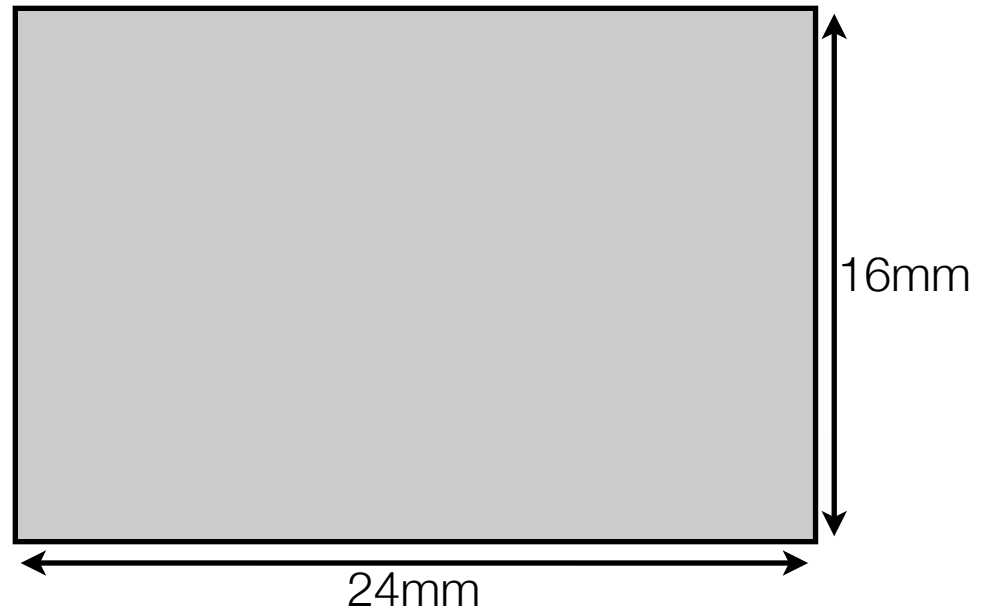
Image from [http://en.wikipedia.org/wiki/Crop\\_factor](http://en.wikipedia.org/wiki/Crop_factor)

# Review

## Focal Length and Perspective



1/2.5"  
6 MP



APS-C (SLR-sized)  
6 MP

Review

Sensor & Pixel Sizes



Canon 1D Mark II, 28mm f/13 1/8 sec, ISO 640



Canon S70, 8mm f/3.5 1/8 sec, ISO 50



Canon 1D Mark II, 28 mm f/3.5 1/100 sec, ISO 640

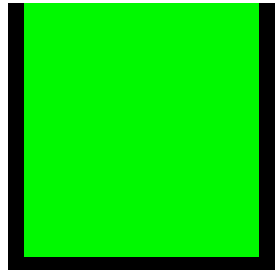
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[www.clarkvision.com](http://www.clarkvision.com)

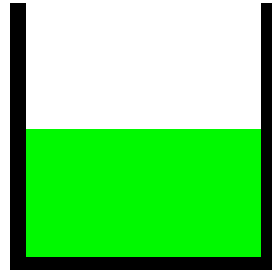
Image from [http://www.clarkvision.com/photoinfo/dof\\_myth/](http://www.clarkvision.com/photoinfo/dof_myth/)

# Review

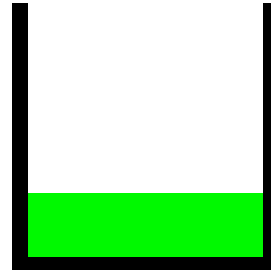
## Depth of Field



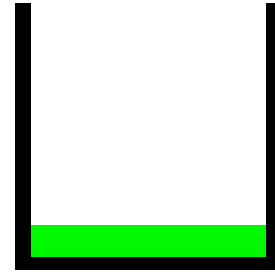
100



200



400



800

Review

Full capacity of pixels at ISOs

Passive Pixel Sensors

CCD

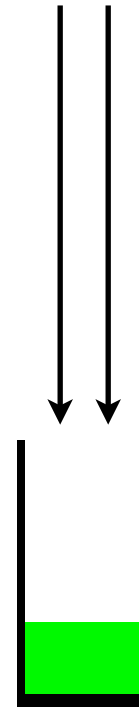
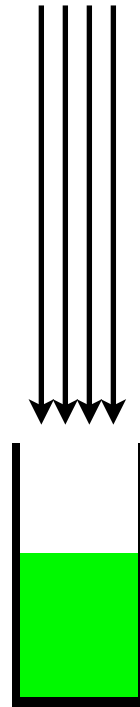
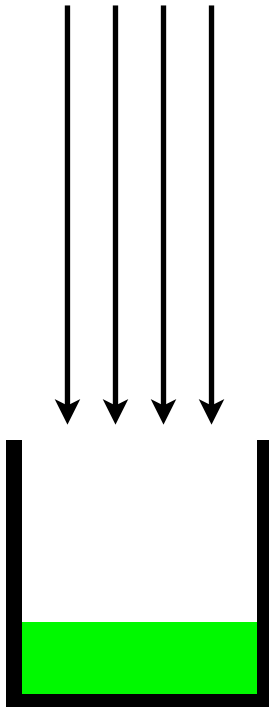
Active Pixel Sensors

CMOS

JFET LBCAST

Digital Cameras

Sensors



Sensors

Pixel Size

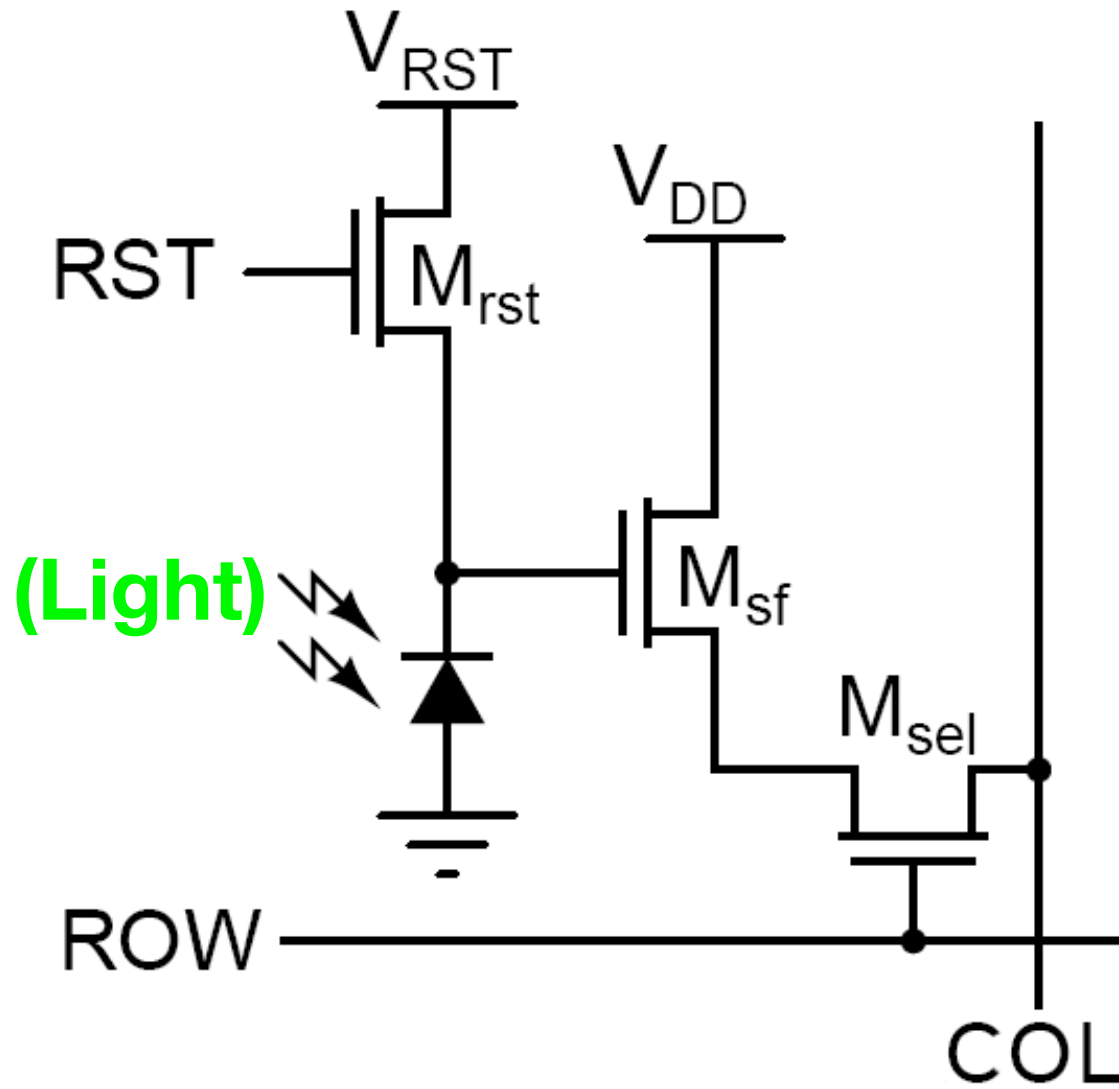


Image from [http://en.wikipedia.org/wiki/Active\\_pixel\\_sensor](http://en.wikipedia.org/wiki/Active_pixel_sensor)

Sensors

Pixels



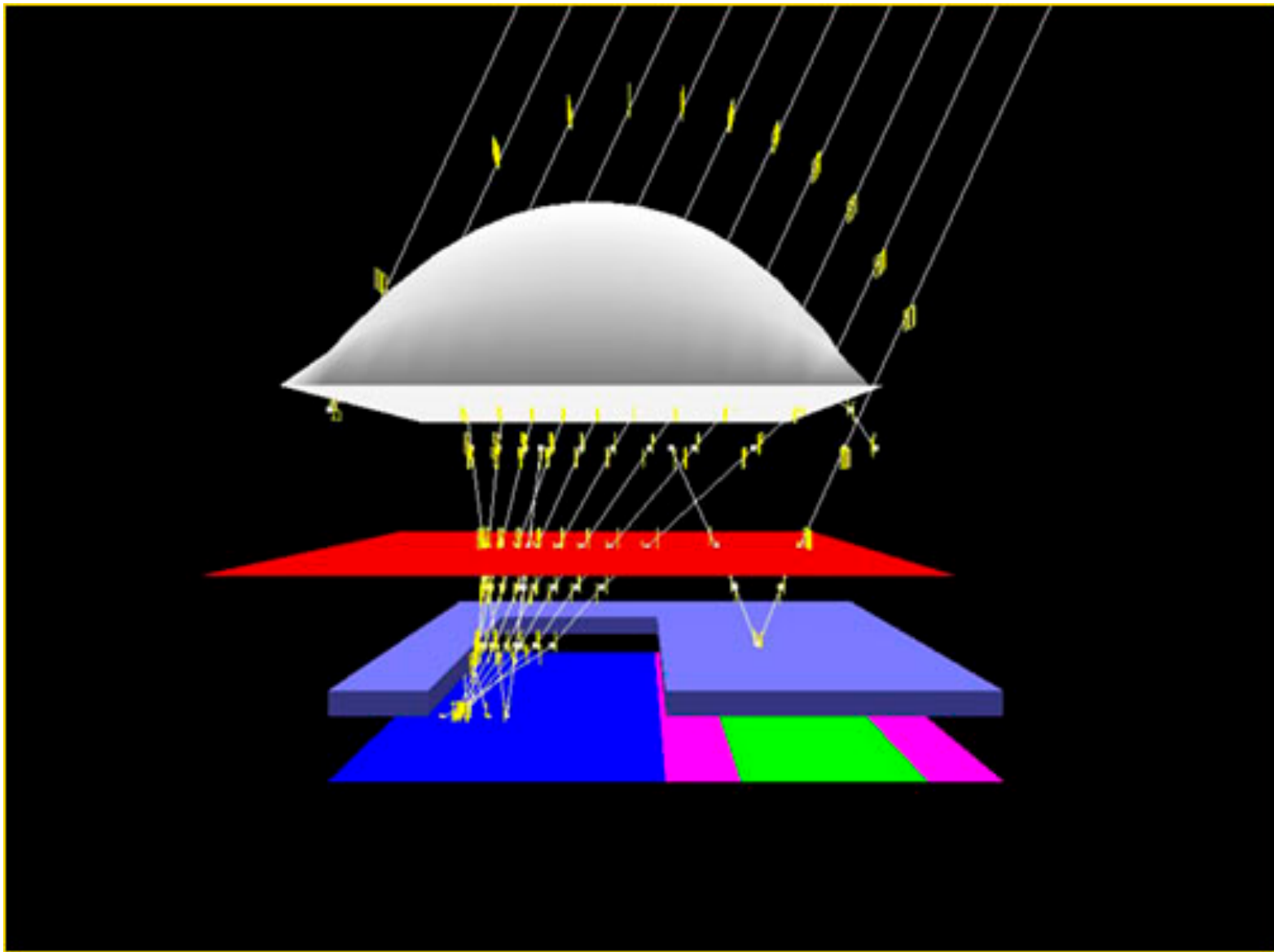


Image from Eastman Kodak, from <http://www.luminous-landscape.com/essays/kodak-iss.shtml>

Sensors

Microlens

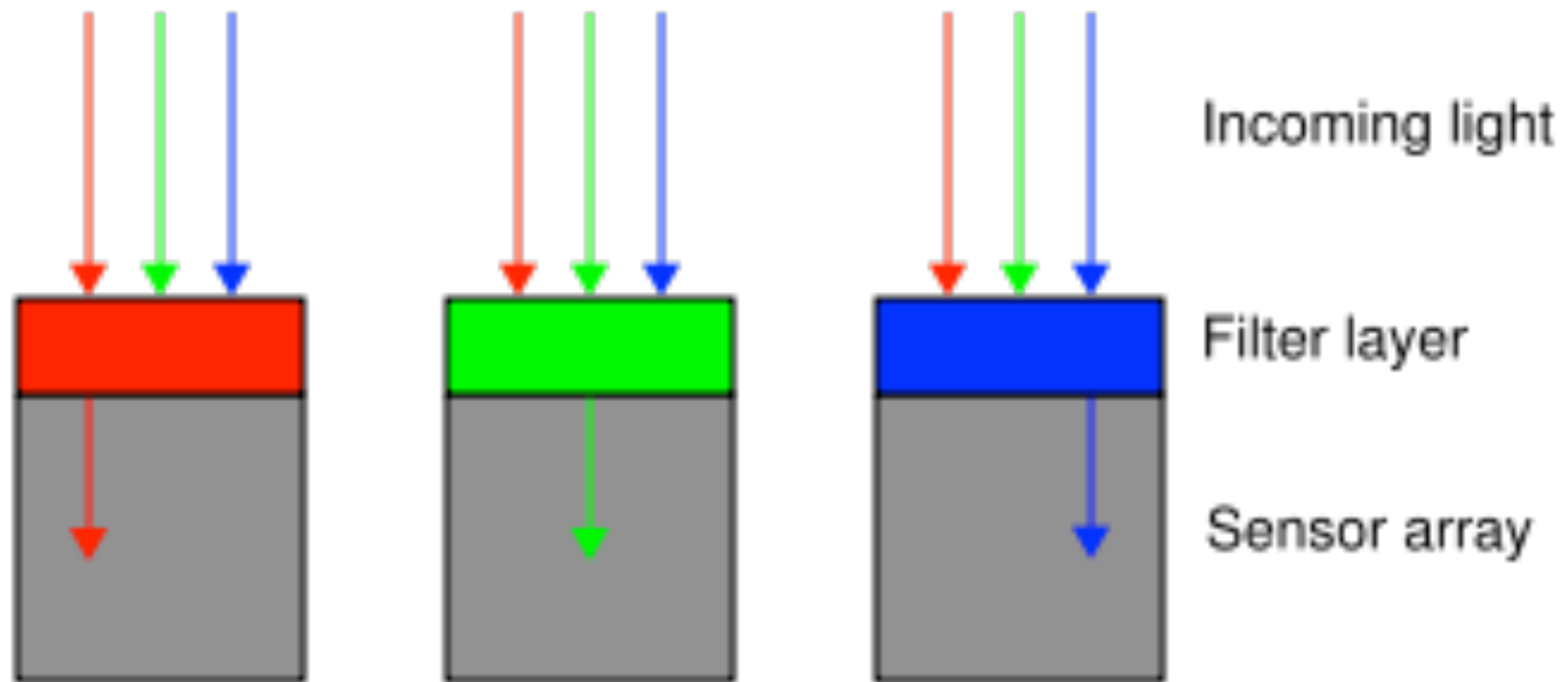


Image from [http://en.wikipedia.org/wiki/Bayer\\_filter](http://en.wikipedia.org/wiki/Bayer_filter)

Sensors

Color Filter Arrays

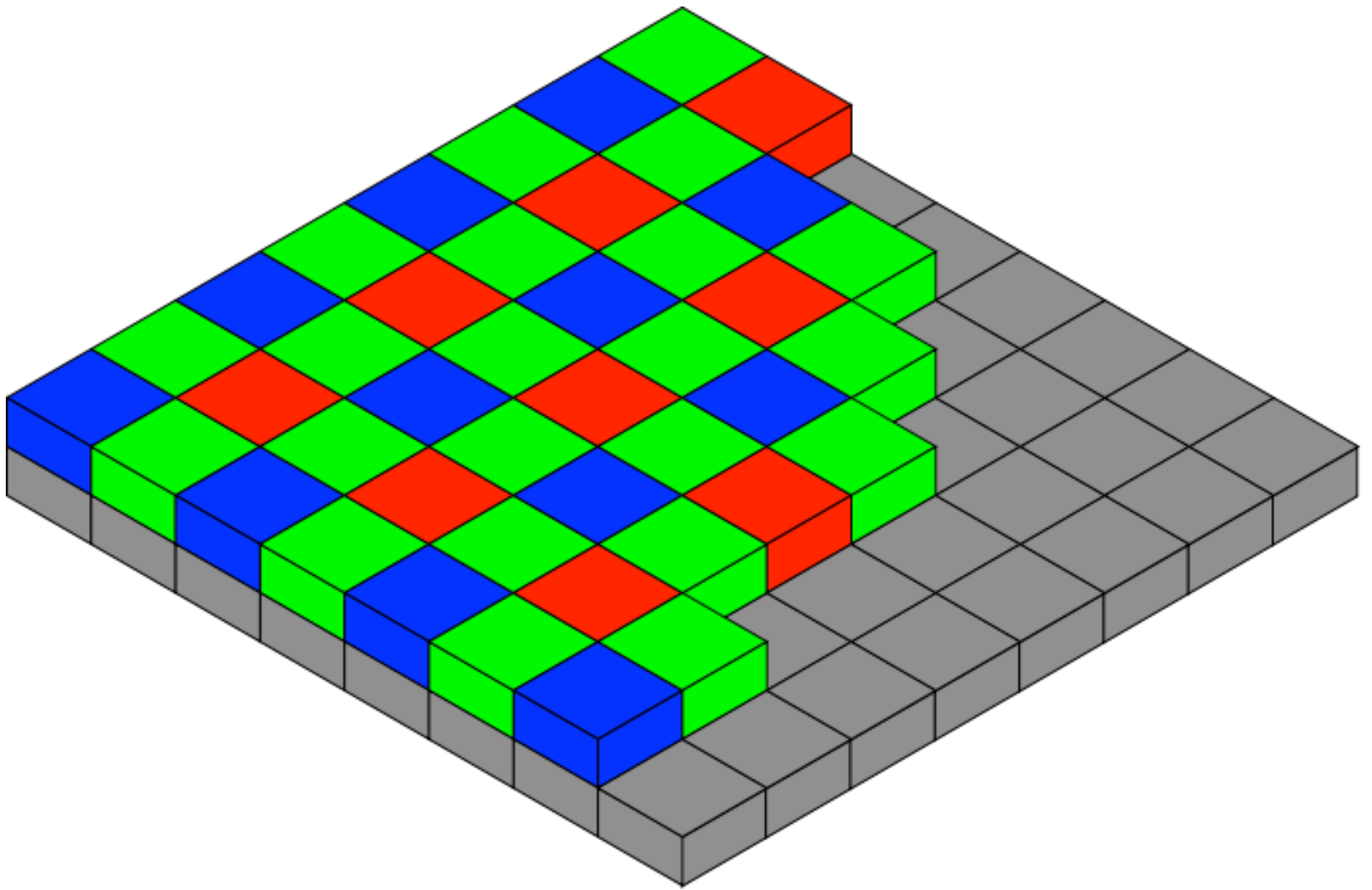
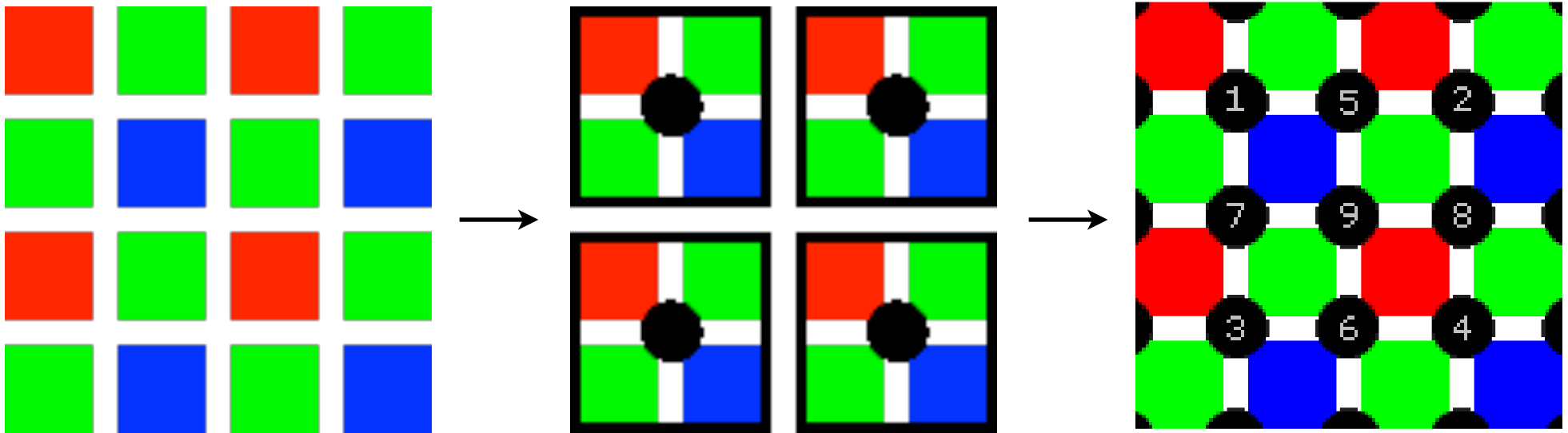


Image from [http://en.wikipedia.org/wiki/Bayer\\_filter](http://en.wikipedia.org/wiki/Bayer_filter)

# Color Filter Arrays

## Bayer Filter



Images from <http://www.cambridgeincolour.com/tutorials/sensors.htm>

# Color Filter Arrays

## Demosaicing

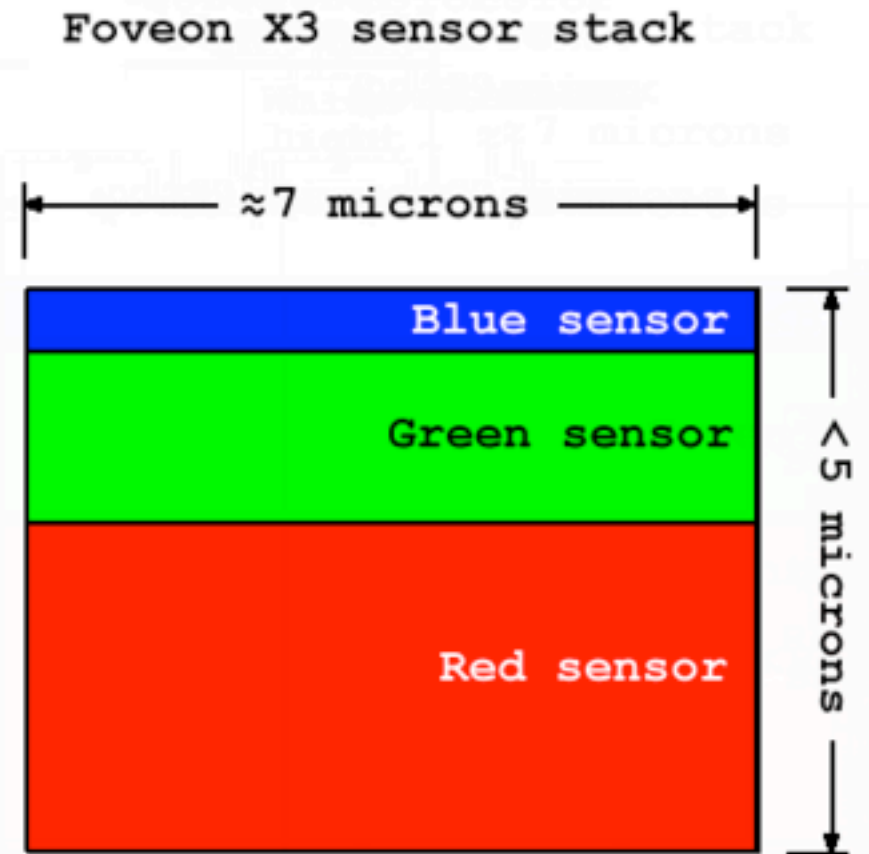
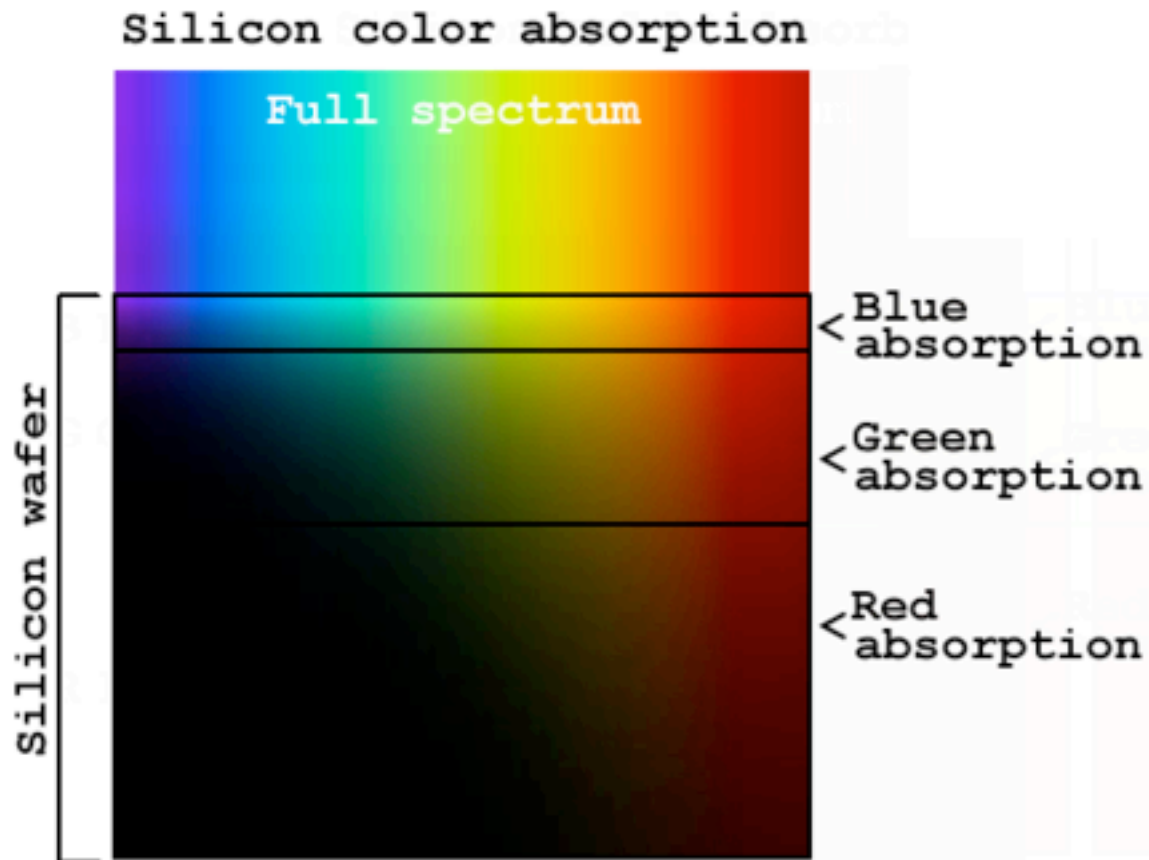
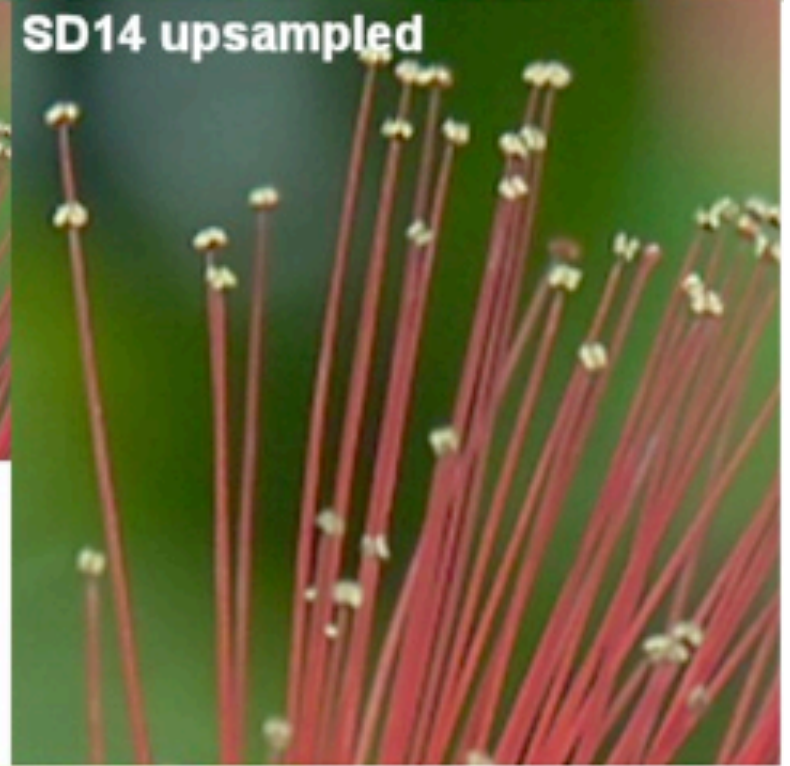
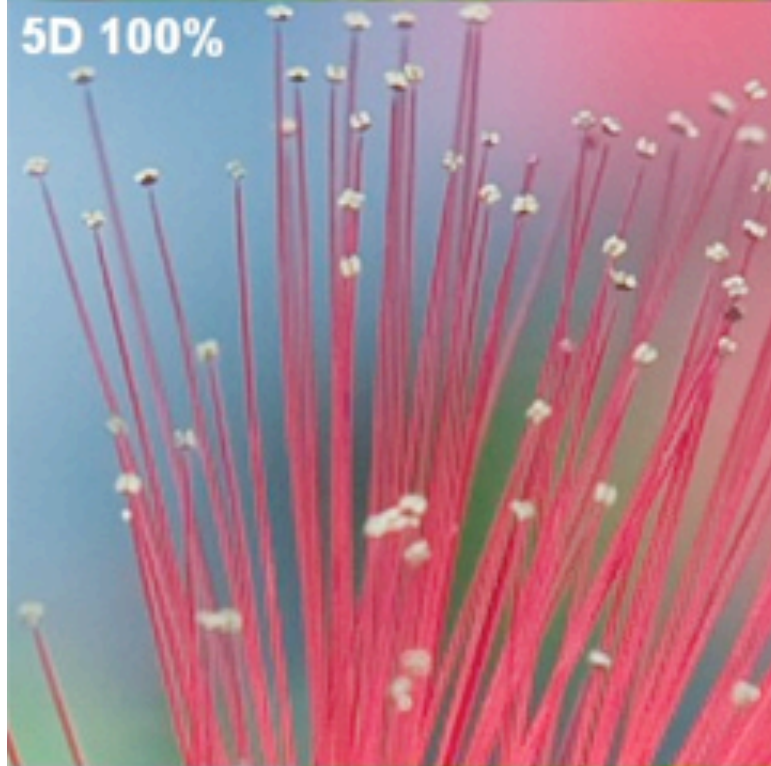


Image from [http://en.wikipedia.org/wiki/Foveon\\_X3\\_sensor](http://en.wikipedia.org/wiki/Foveon_X3_sensor)

Sensors

Foveon X3



Images from <http://www.ddisoftware.com/sd14-5d/>

Sensors

Foveon X3





Foveon



Bayer

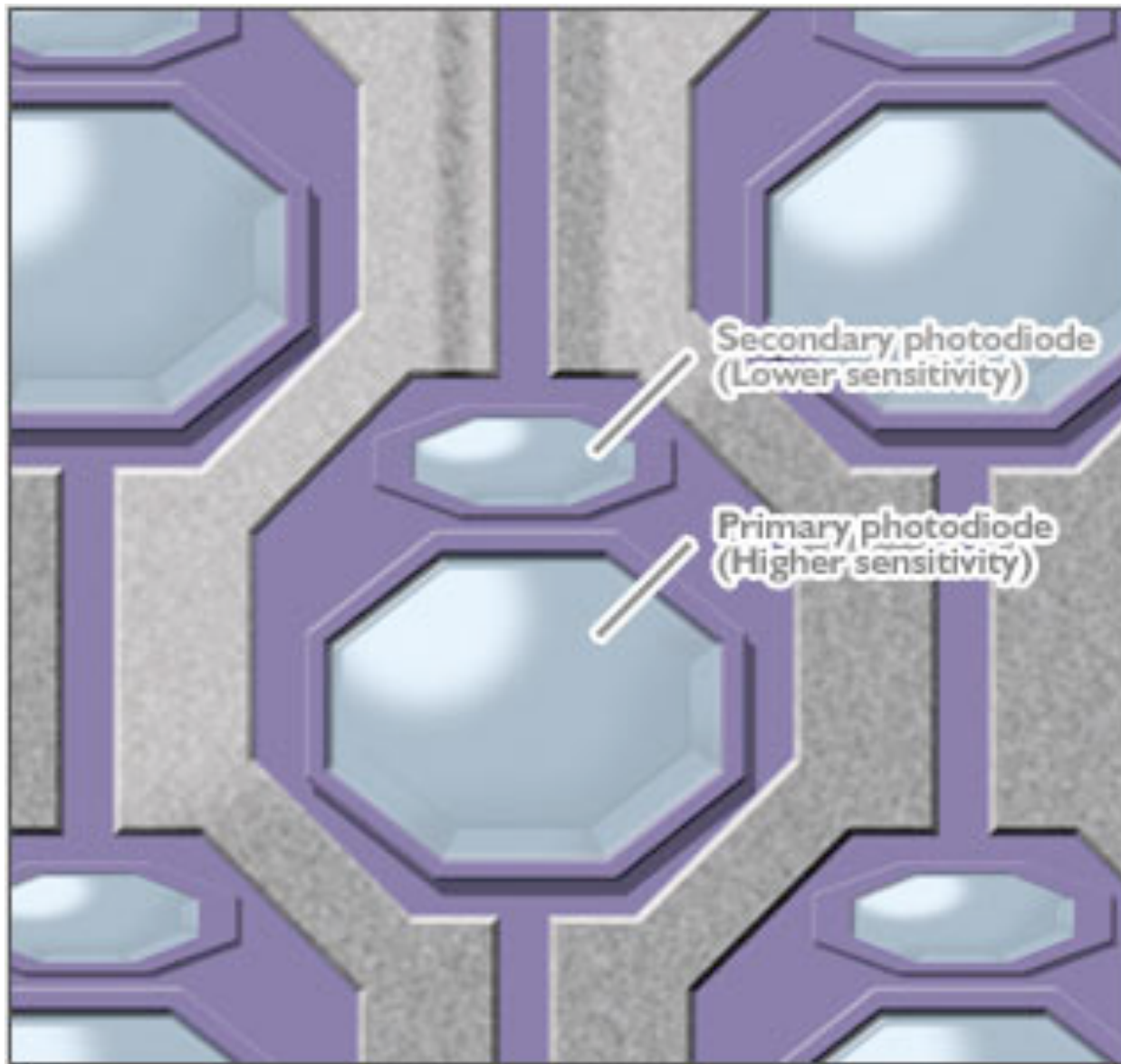


Bayer+LP (AA)

Images from <http://www.ddisoftware.com/reviews/sd9-v-bayer/>

Sensors

Low-Pass (Anti-Aliasing) Filter



Images from <http://www.dpreview.com/news/0301/03012202fujisuperccdsr.asp>

# Sensors

## Fujifilm SuperCCD SR





309s, ISO 100

Photo by Dan Armendariz, 2009

# Digital Cameras

## Histograms



Images from [http://www.dpreview.com/learn/?/Glossary/Digital\\_Imaging/dynamic\\_range\\_01.htm](http://www.dpreview.com/learn/?/Glossary/Digital_Imaging/dynamic_range_01.htm)

# Digital Cameras

## Dynamic Range





Images from [http://www.dpreview.com/learn/?/Glossary/Digital\\_Imaging/dynamic\\_range\\_01.htm](http://www.dpreview.com/learn/?/Glossary/Digital_Imaging/dynamic_range_01.htm)

# Digital Cameras

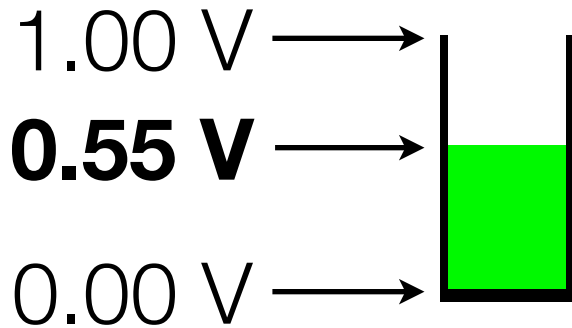
## Dynamic Range

|      |        |
|------|--------|
| Bit  | 0 or 1 |
| Byte | 8 bits |

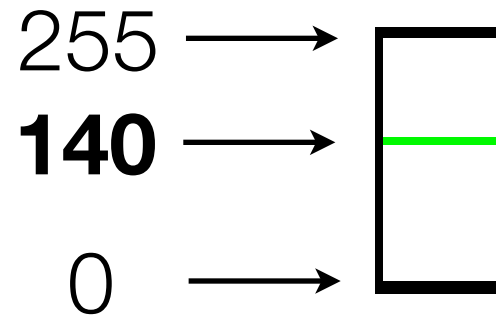
Bits and Bytes

Refresher

Analog Sensor



8-bit Sampling

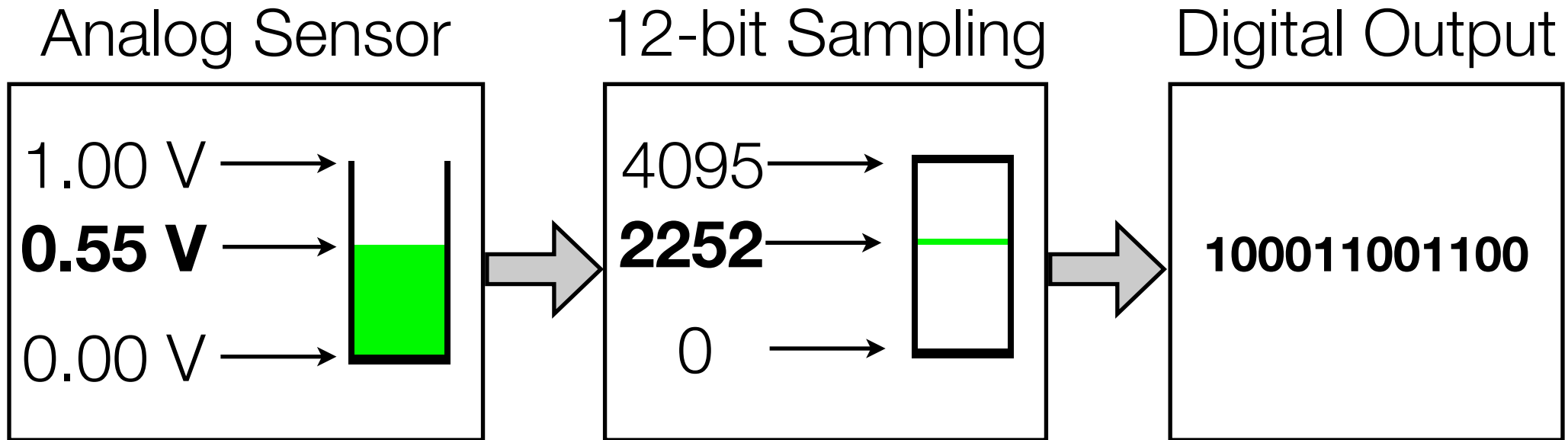


Digital Output

**10001100**

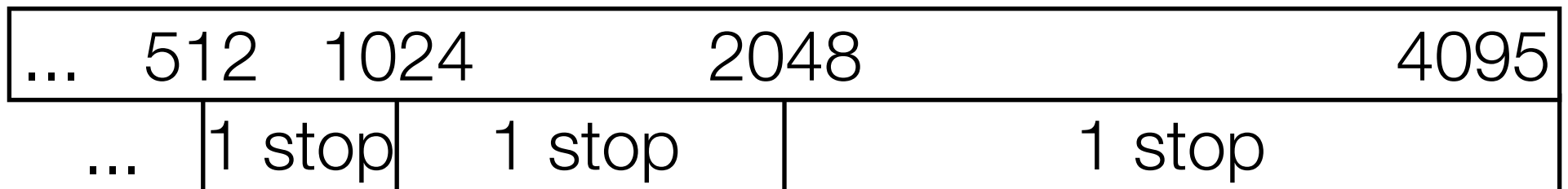
Digital Cameras

Analog to Digital Converter (ADC)



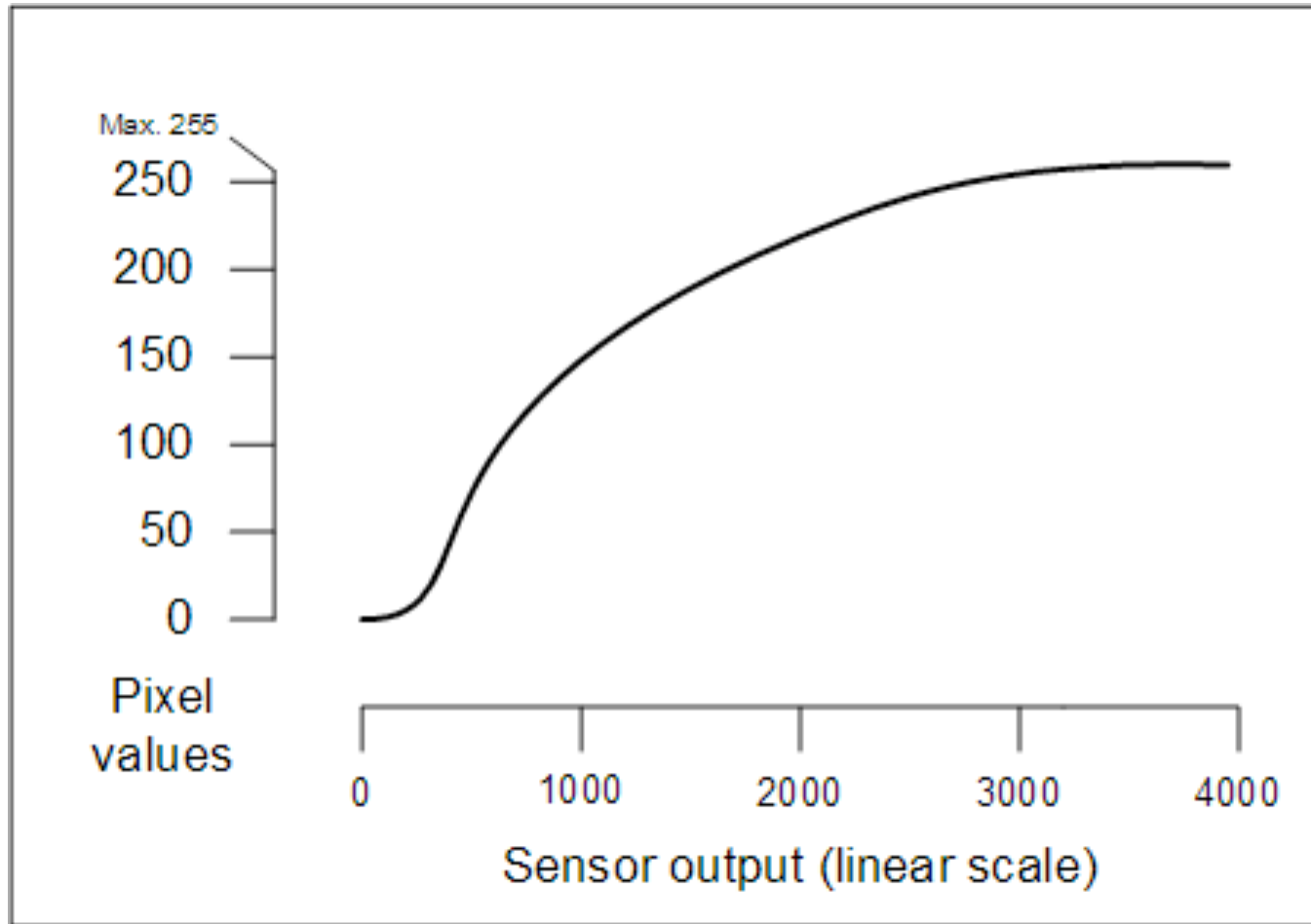
Digital Cameras

Analog to Digital Converter (ADC)



Digital Cameras

Sensor Linearity



Images from <http://www.covingtoninnovations.com/dslr/Curves.html>

# Digital Cameras

## Tonal Curve



|                        | <b>RAW</b>       | <b>JPEG</b> |
|------------------------|------------------|-------------|
| <b>Bit depth</b>       | 10-, 12-, 14-bit | 8-bit       |
| <b>Tonal Curve</b>     | Not applied      | Applied     |
| <b>White Balance</b>   | Not set          | Set         |
| <b>Compression</b>     | Lossless         | Lossy       |
| <b>Portability</b>     | Nonstandard      | Standard    |
| <b>Post-Processing</b> | Required         | Optional    |

Digital Cameras

RAW vs JPEG!

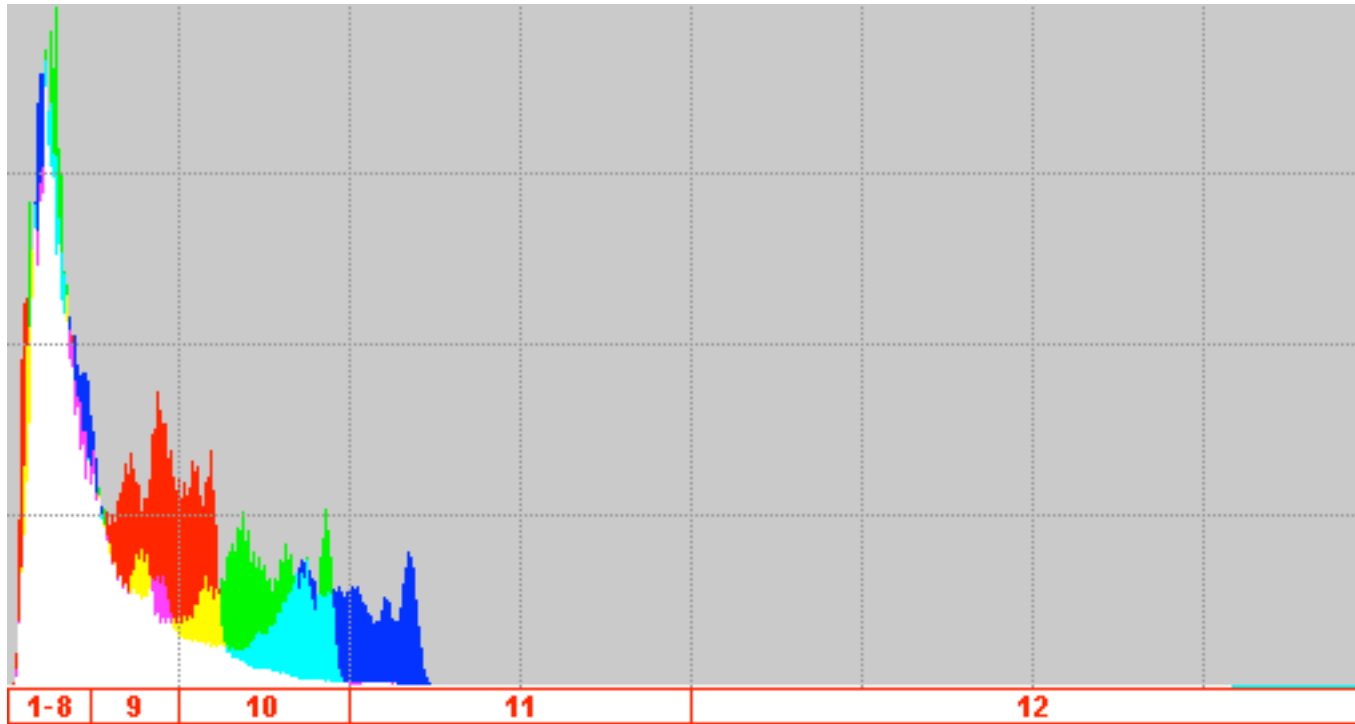


Image from [http://www.guillermoluijk.com/tutorial/dcraw/index\\_en.htm](http://www.guillermoluijk.com/tutorial/dcraw/index_en.htm)

# Digital Cameras

“Expose to the Right”

# Computer Science E-7

## Exposing Digital Photography

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