Improved Light Sensitivity in Color CCD Image Sensors

The KODAK TRUESENSE Color Filter Pattern

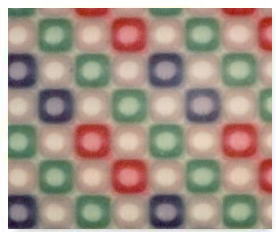
Michael DeLuca
Image Sensor Solutions

Kodak








Kodak Image Sensor Solutions

A Global Leader in Image Sensors

- Over 35 years of technology innovation
- Leading provider of performance CCDs
- Technology innovator in CCD and CMOS

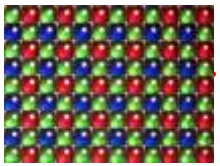
Worldwide Presence

- Rochester, NY based R&D, Manufacturing
- WW sales and applications support

Strong IP position

- Key element of Kodak's Digital Portfolio

History of Sensor Innovation at Kodak



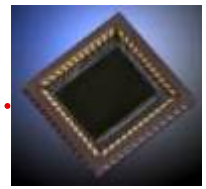
Bayer Pattern Array (1975)

1975

First Prototype Digital Camera (1976)

1980

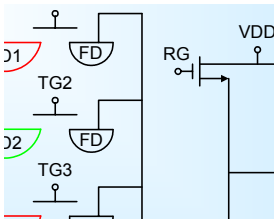
1985



First Megapixel Sensor (1986)

1990

First SLR Digital Camera (1991)



4T Shared, Pinned Diode CIS Technology (2000)

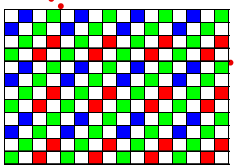
2000

Mars Rover Camera (1997)

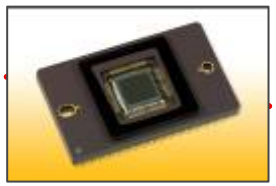
1995

1st Consumer Digital Camera – KODAK Technology in Apple QuickTake (1994)

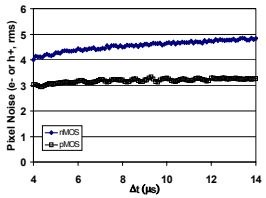
2005



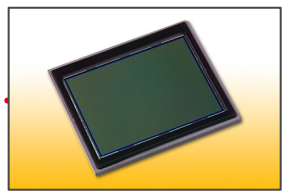
KODAK TRUESENSE Color Filter Pattern (2007)



KODAK TRUESENSE 5.5-Micron Interline Transfer CCD Platform (2007)



KODAK TRUESENSE CMOS Pixel (2008)



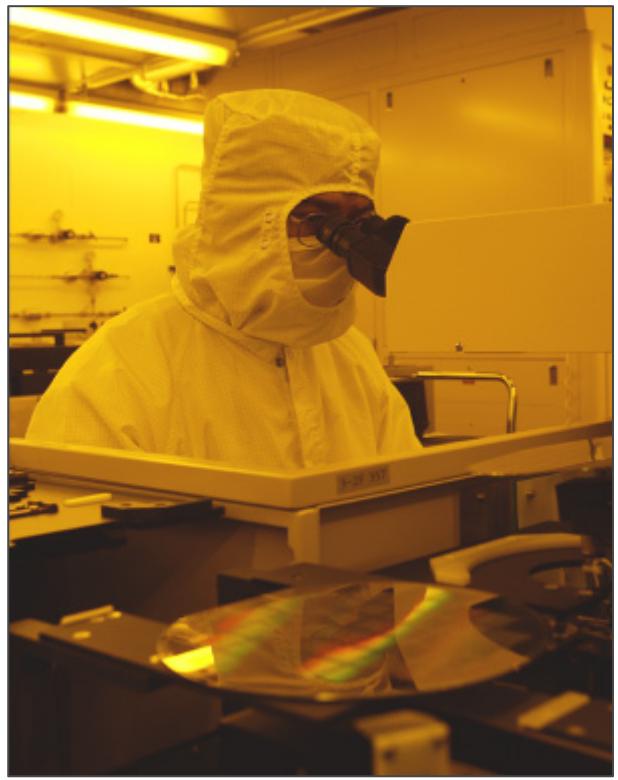
50 Megapixel Sensor (2008)

R&D Target: Increase Sensor Light Sensitivity

Expand sensor use for light-starved applications

Retain full color imaging and high image quality

Adapt to standard manufacturing processes

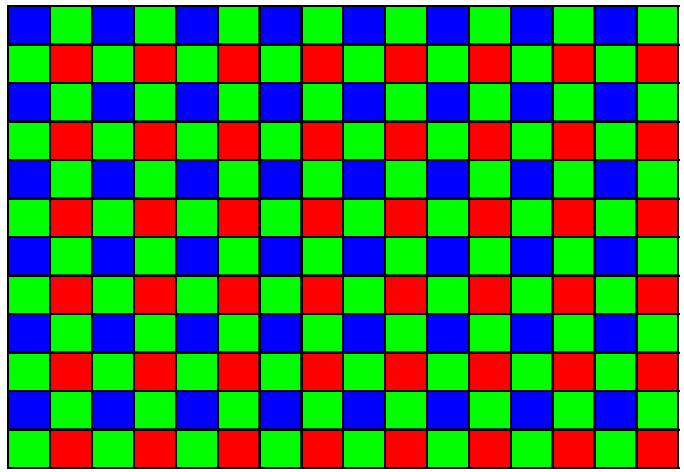


Bayer Color Filter Pattern

De facto standard for one-chip color imaging

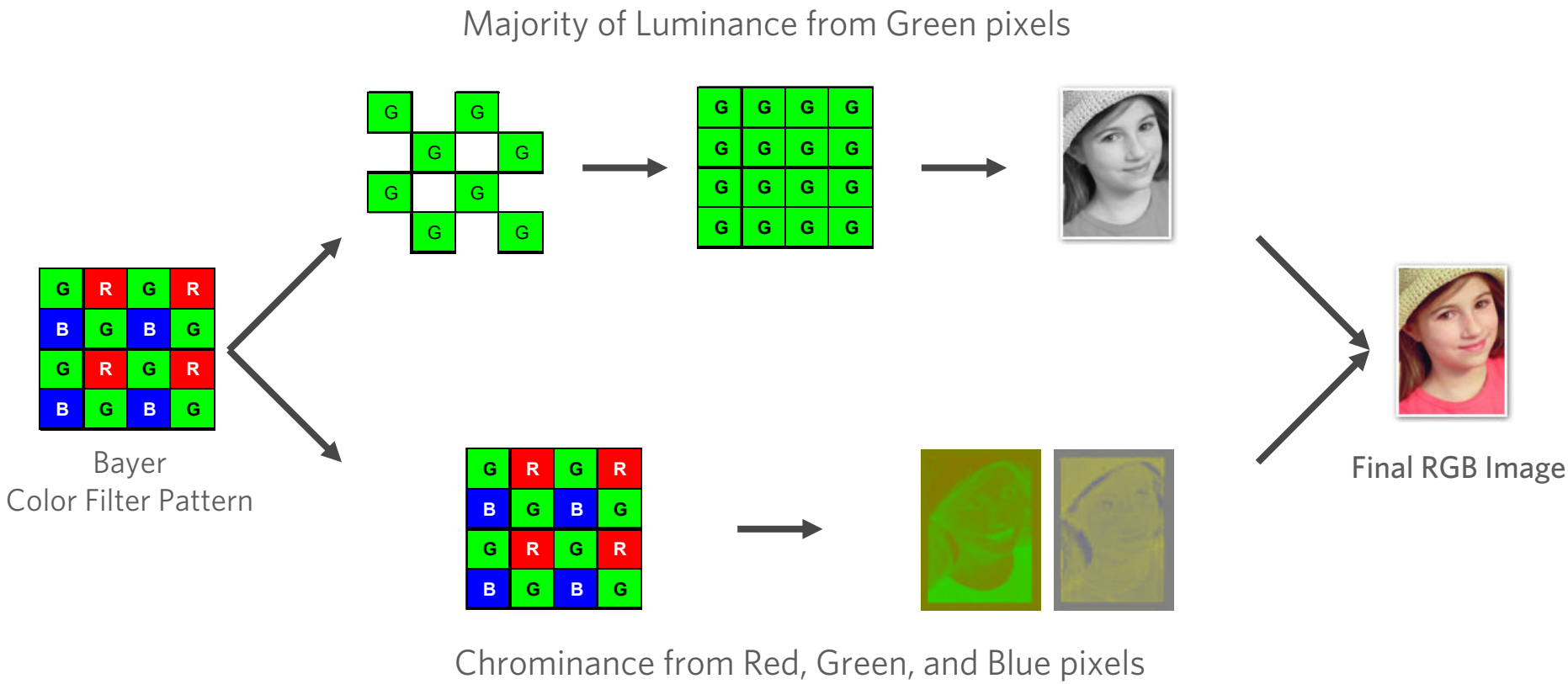
Kodak Patent (Bryce Bayer, 1976)

2001 Emmy from National Academy of Television Arts and Sciences



Bayer Color Filter Pattern

Bayer Color Filter



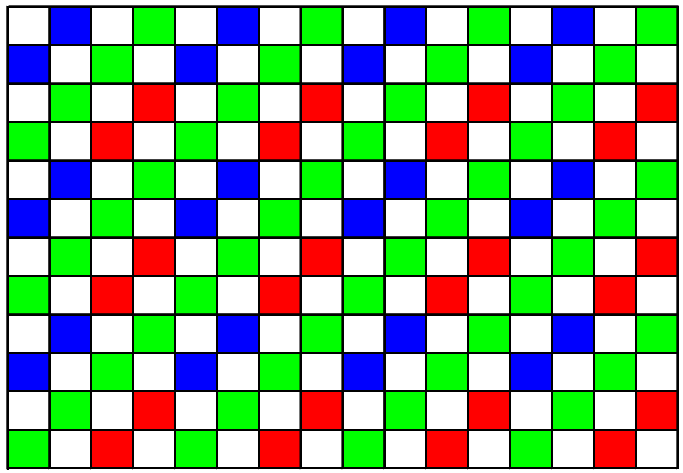
KODAK TRUESENSE Color Filter Pattern

Panchromatic (“clear”) pixels added to standard Red, Green, and Blue array

Pan pixels provide increased sensitivity by detecting all visible wavelengths

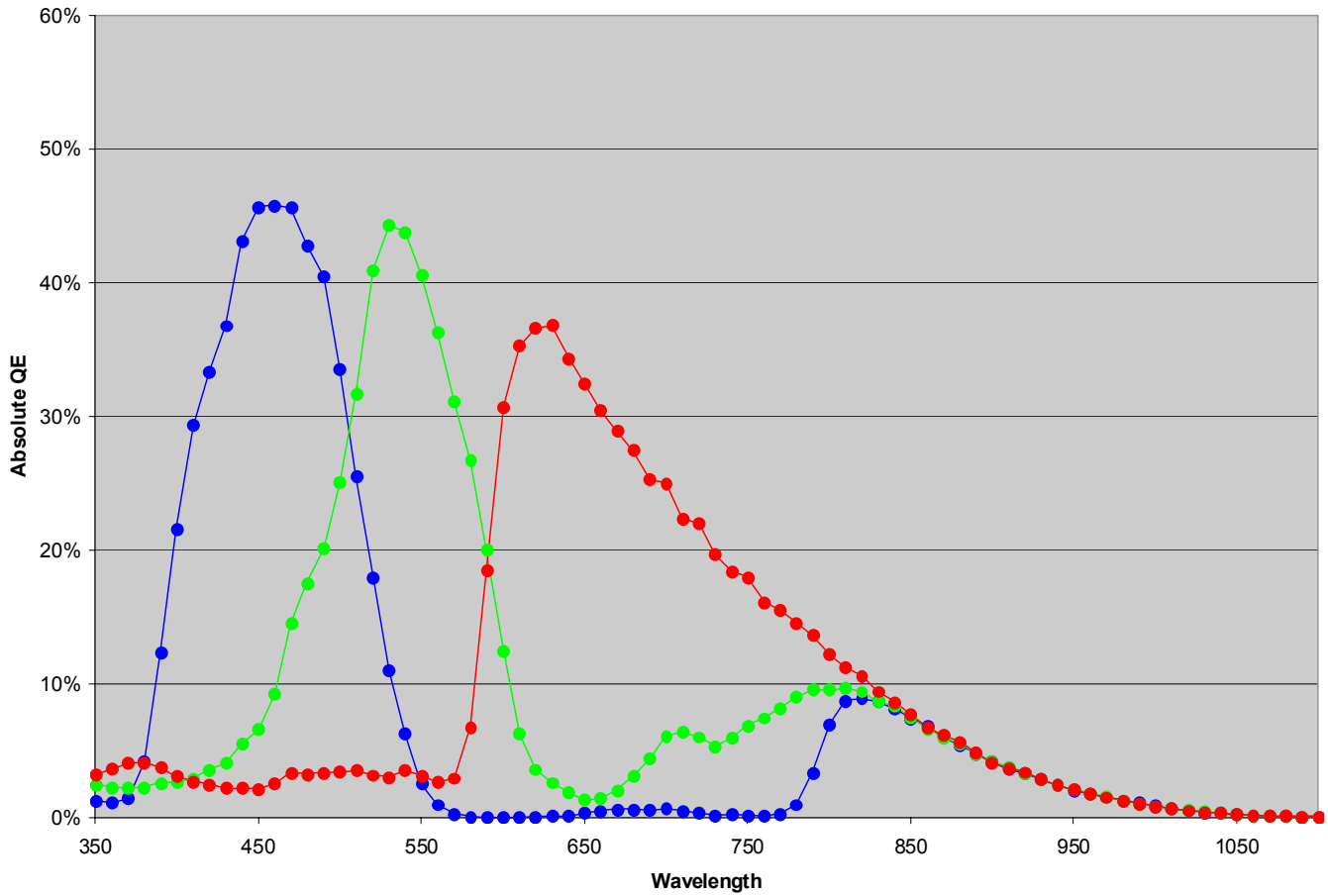
RGB pixels collect color information for final color image

Standard sensor manufacturing process

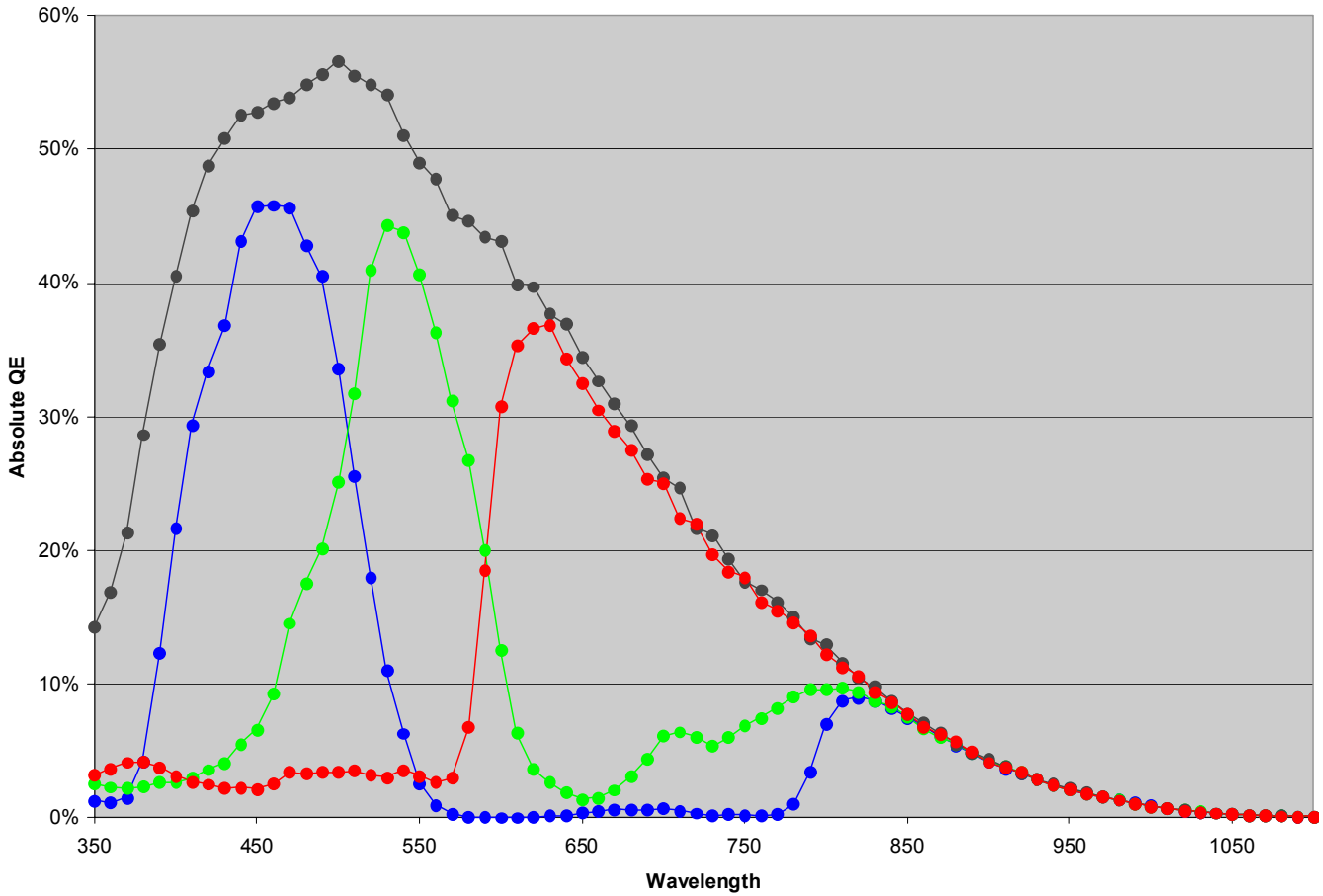


KODAK TRUESENSE Color Filter Pattern

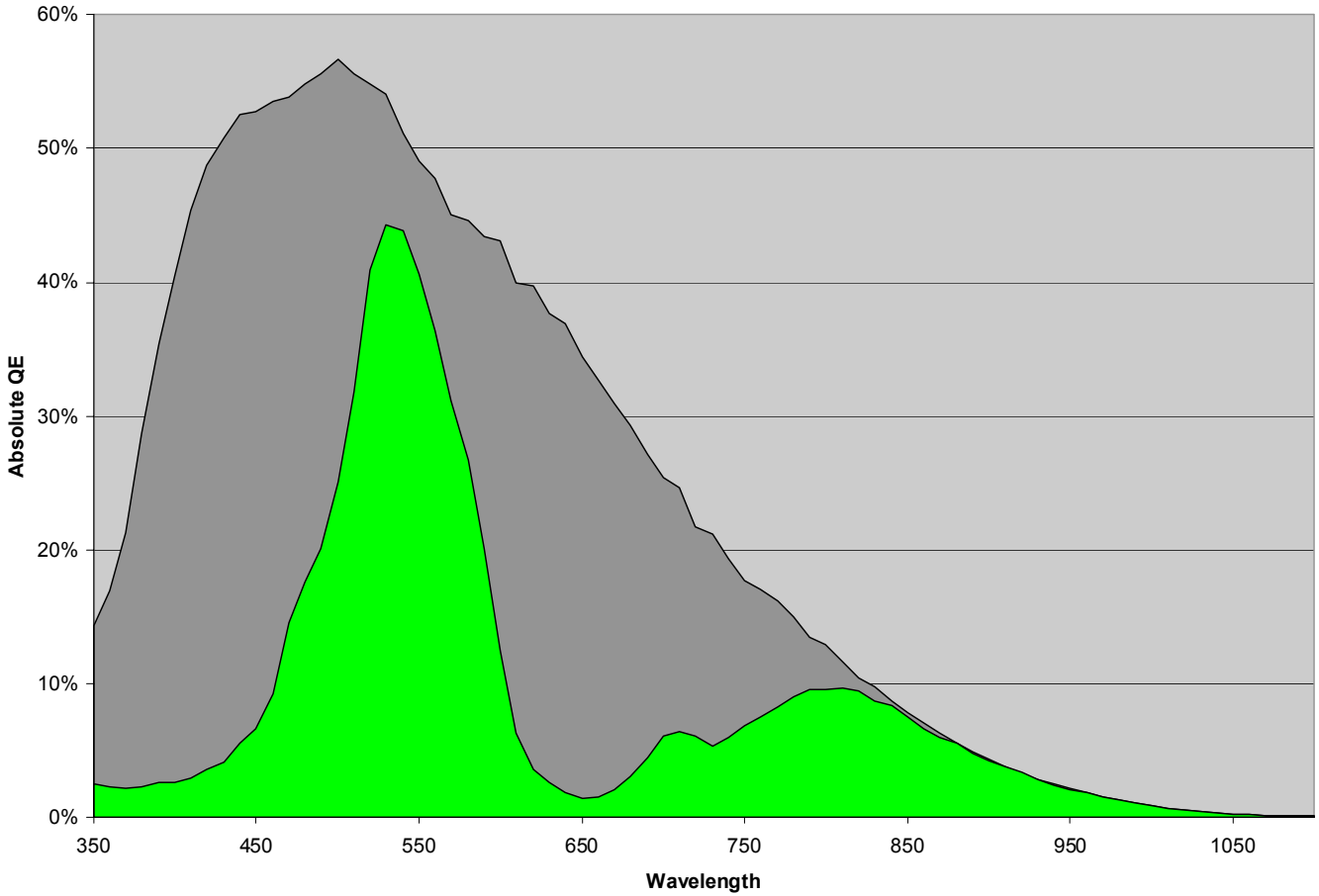
Panchromatic Pixels for Increased Light Sensitivity



Panchromatic Pixels for Increased Light Sensitivity

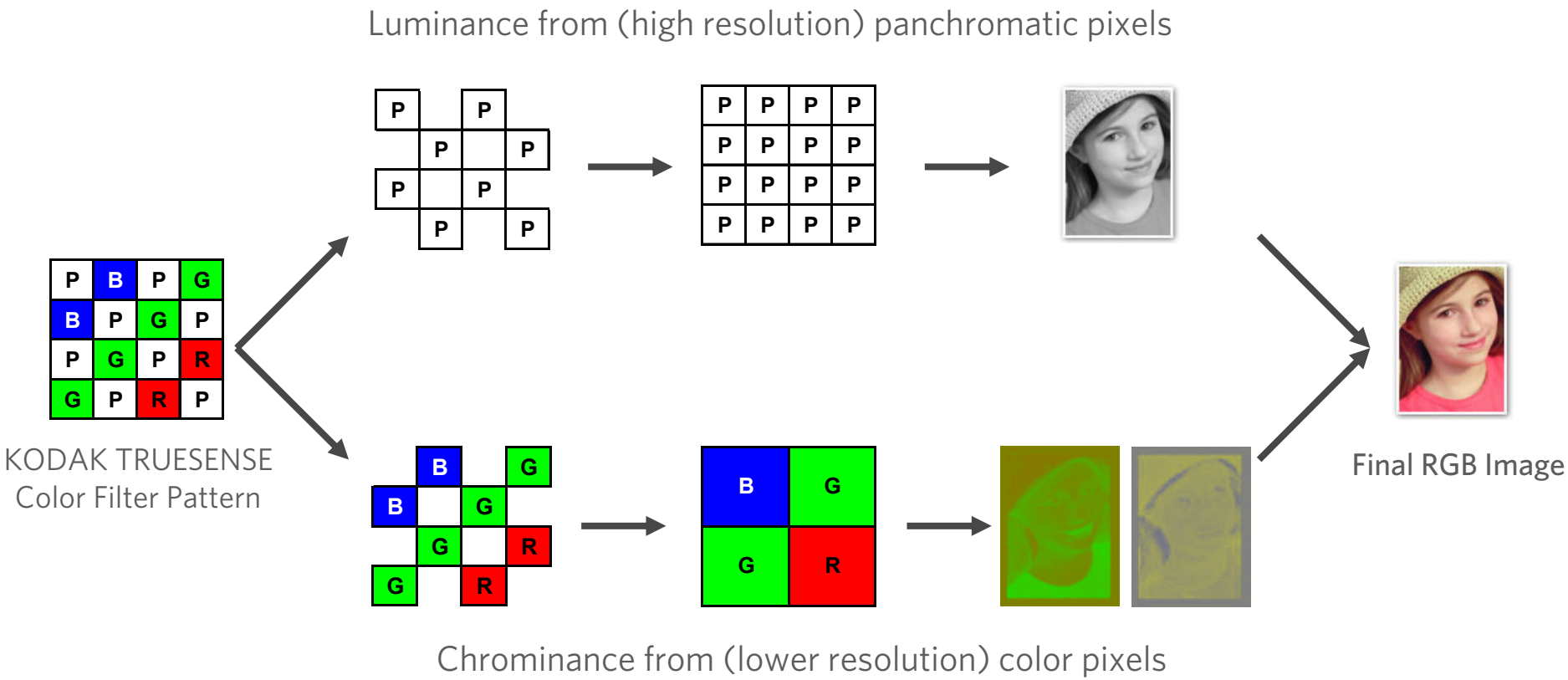


Panchromatic Pixels for Increased Light Sensitivity



Broad panchromatic absorption band increases light sensitivity

KODAK TRUESENSE Color Filter Pattern



A New Approach to Full Color Imaging

Bayer CFA

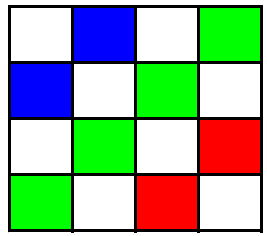
- Overall sensitivity limited by CFA absorptions
- 50% of pixels (Green) used for luminance channel
- Chrominance from 100% of all pixels
  - R, G, and B pixels used for chrominance channels
- Customized, optimized image processing paths

KODAK TRUESENSE CFA

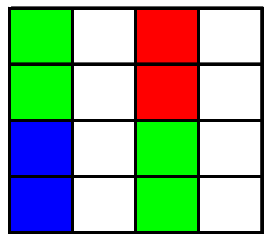
- Overall sensitivity enhanced with Panchromatic pixels
- 50% of pixels (Panchromatic) used for luminance channel
- Chrominance from 50% of all pixels
  - R, G, and B pixels used for chrominance channels
- New image processing path

Not One, but a Family of Patterns

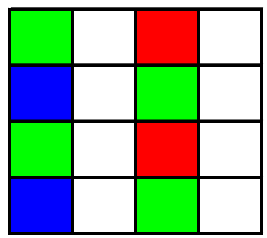
- Sensitivity vs Color
- Available processing power
- Ease of decimating to Bayer RGB for video
- Other



Pattern A



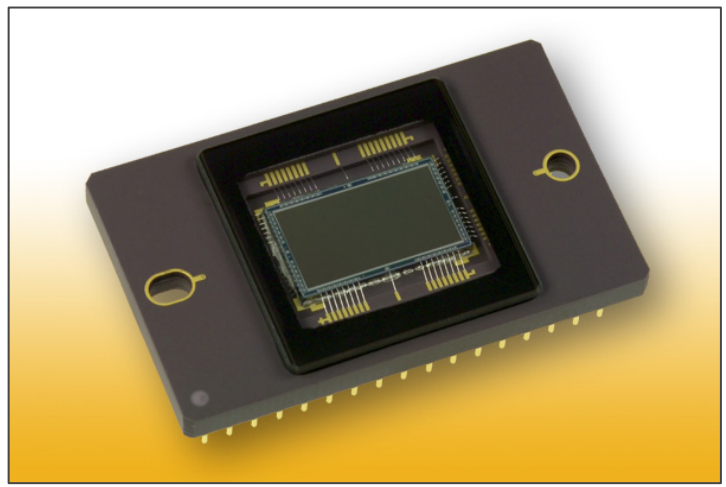
Pattern B



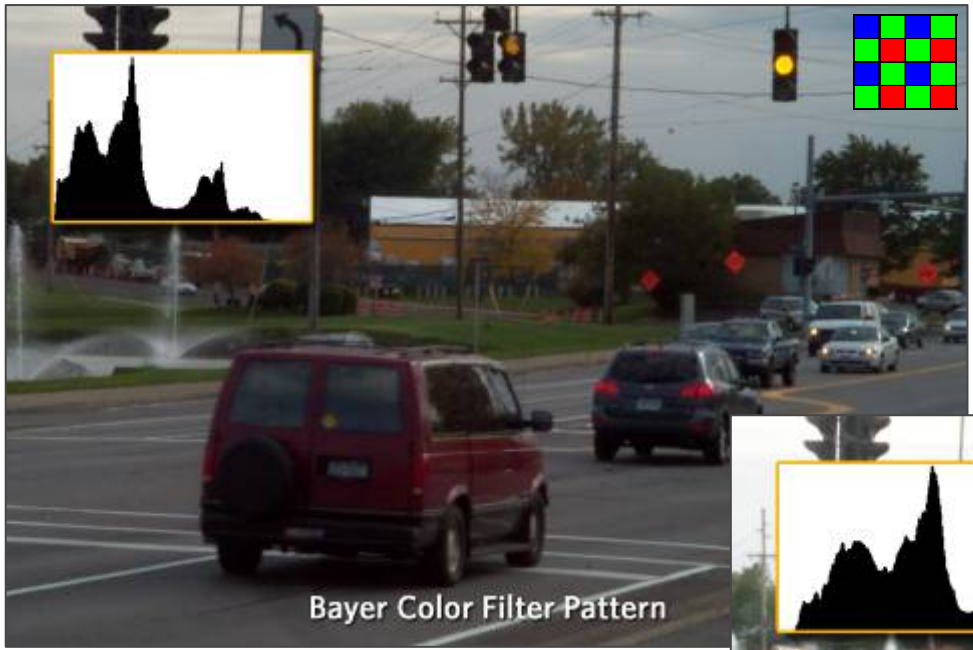
Pattern C

Development Vehicle: KODAK KAI-02150 Image Sensor

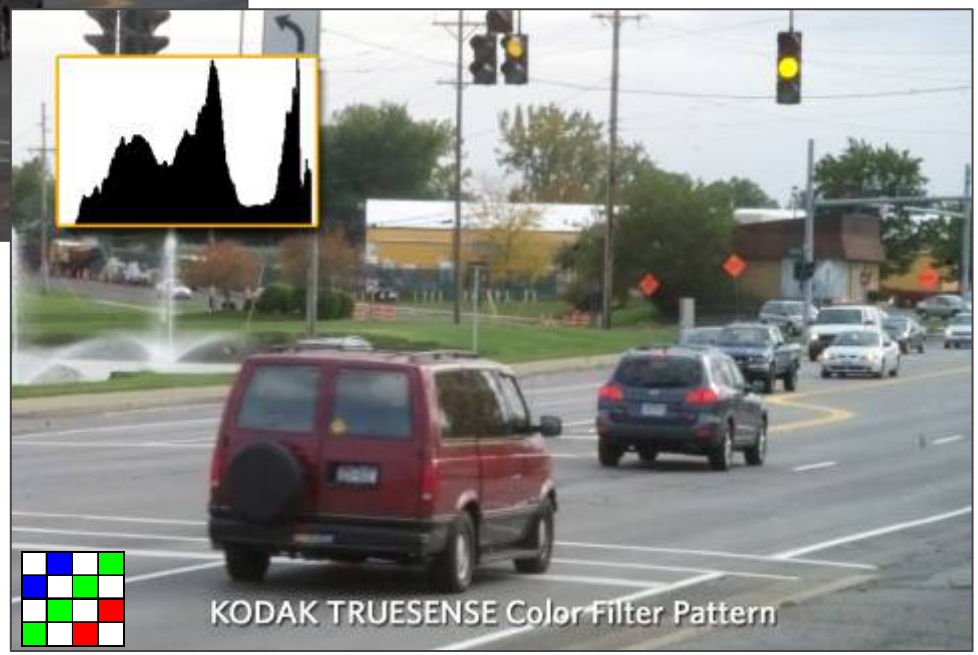
- 1920 x 1080 pixels for 1080p HDTV resolution (16:9 aspect ratio)
- 2/3” optical format
- Up to 64 fps
- -100 dB smear for enhanced image quality
- High Sensitivity Output Amplifier enables low noise operation
- High Dynamic Range for detail in Shadows and Highlights



KODAK TRUESENSE Color Filter Pattern



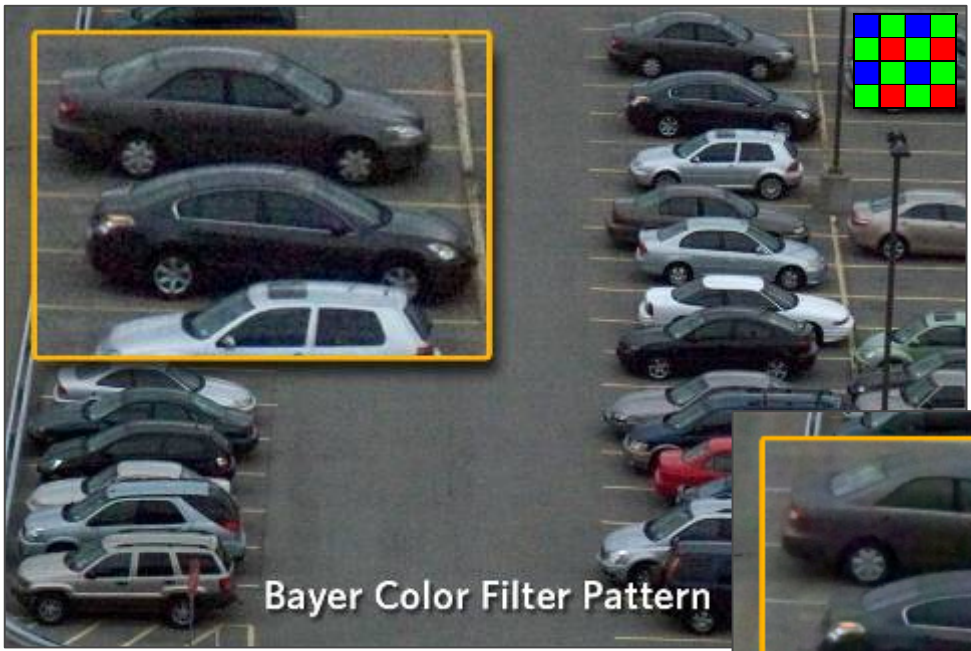
Standard Color Image Capture



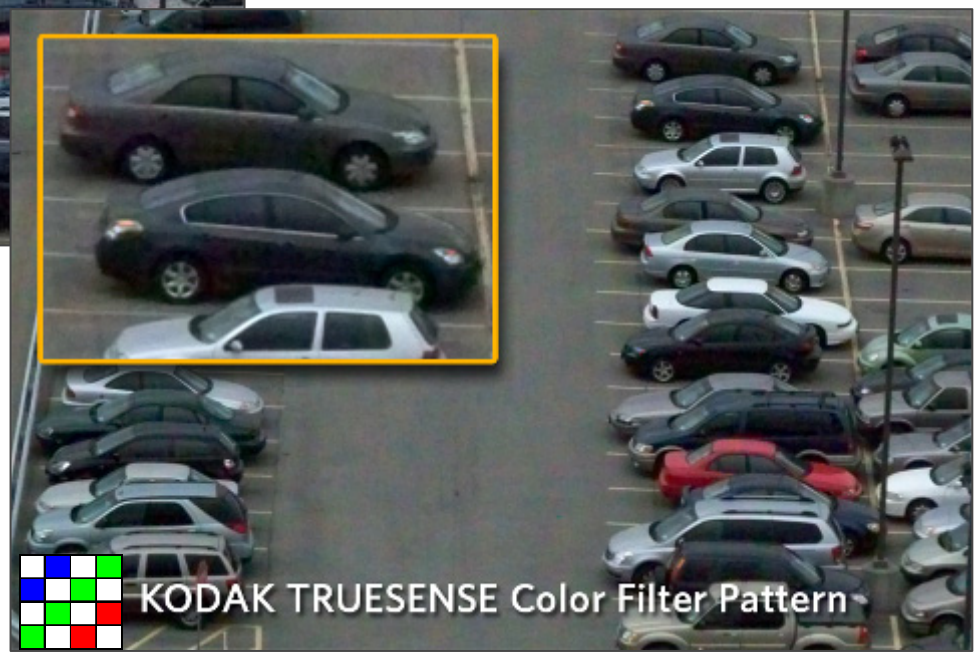
Extra Light Sensitivity from
Panchromatic pixels

Simultaneous image capture under identical conditions

KODAK TRUESENSE Color Filter Pattern



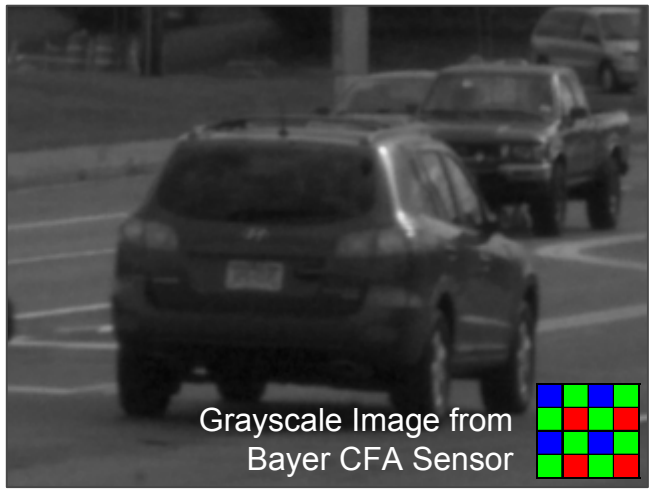
Standard Color Image Capture

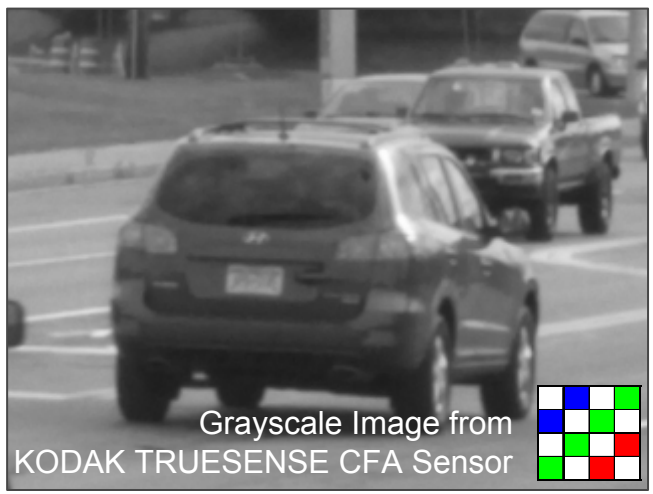


Reduced Image Noise from
Panchromatic pixels

Camera gain adjusted for matched exposure

Color Imaging with Monochrome Sensitivity

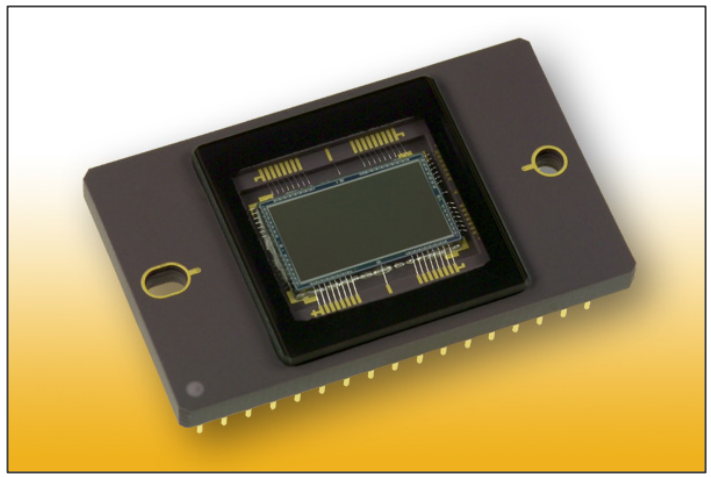




Simultaneous image capture under identical conditions

Implementation

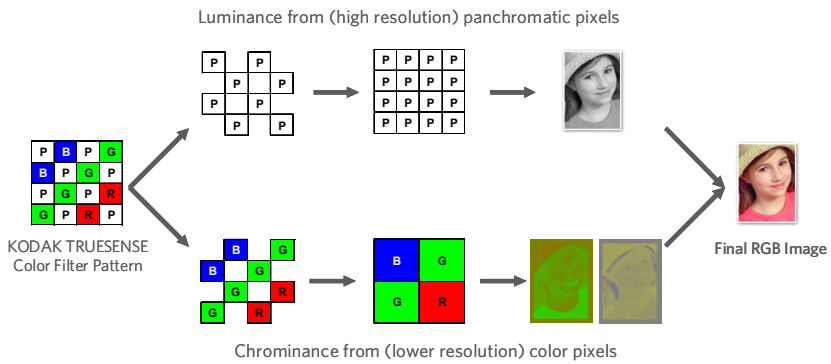
Sensor with KODAK TRUESENSE Color Filter Pattern



KODAK KAI-02150 Image Sensor

Image Processing Guidelines

Sample code

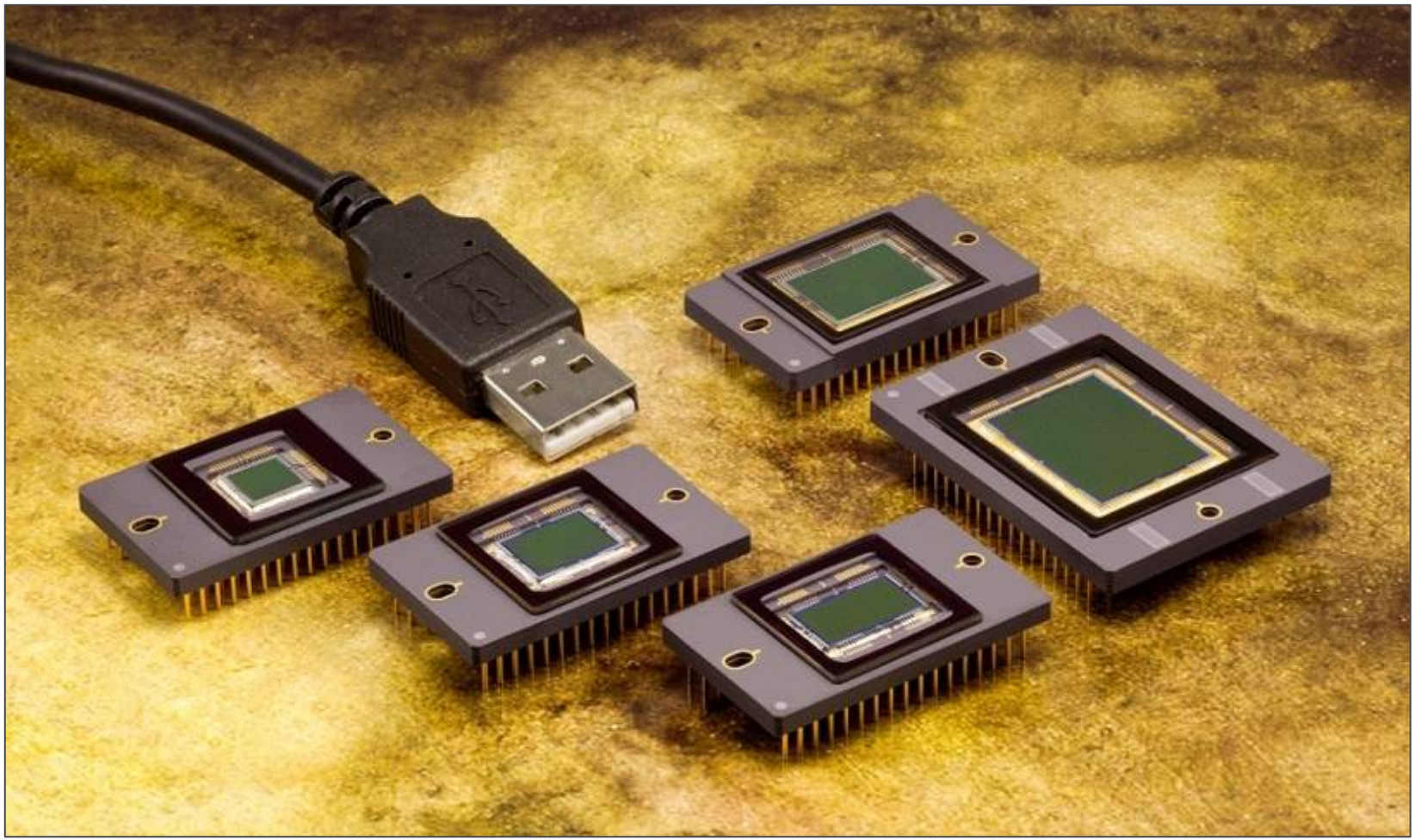


Low-Light Opportunities

Traffic Systems

Security / Surveillance

An Integrated Portfolio of Products and Technologies



Kodak