Scientific CCD vs. Consumer Digital Cameras

Scientific Camera

Advantages:

- Real time viewing of the image (fast frame rate)
  - Provides accurate and fast focusing and color adjustment
- Uses dedicated video photo lenses for minimal chromatic aberrations and flattest field possible. It also provides the best match of microscope eyepiece field of view and actual captured field of view.
- Fast capture straight to the computer for immediate image analysis and manipulation.
- Specialized CCD sensors for:
  - Maximum light sensitivity
  - Uniform color across the field
  - Grade 0 sensors for NO bad pixel locations (important for image analysis)
- Full camera control from on-screen Viewfinder:
  - Fast learning curve
  - Accurate white balance controls (auto, manual, reference)
  - Control of light metering…get the best exposure setting.
  - Ability to FRAME AVERAGE or FRAME INTEGRATE
  - Ability to adjust input LEVELS for expanding contrast and maximize data acquisition
    - Pre-capture adjustment provides more post-capture adjustment possible
- Works directly with 3rd party analysis software (EMPIX, ImagePro, PhotoShop, etc) using custom drivers providing direct-to-application capture. Saves time and effort.
- TETHERED design so theft potential is greatly minimized. Cannot work as a standalone camera.
- Designed for long service life. Software upgradeable assuring your system will not become obsoleted overnight. SDK (software developers kit) available for specialized applications.

Disadvantages:

- Cost. Much greater than consumer but these are built for heavy use and abuse.
- Portability. Tethered so must be in the vicinity of the controlling PC.

Consumer Camera

Advantages:

- Low cost
- Portable

Disadvantages:

- Typically use CMOS technology for sensors. Inferior for microscopy applications (see CCD vs CMOS)
- Have built-in lense system. Even the best are a compromise of cost/performance specifically for the less demanding application of family photos.
- Requires costly specialized adapter lenses (typ >$300) to connect to a microscope. The image must now go thru 2 sets of lenses (built-in and adapter) before reaching the sensor resulting in chromatic aberrations and non-flat field
- User has minimal control over camera functions. Control access is more difficult due to multi-level menus and tiny control buttons.
- Direct connection to a PC is typically slow so the screen refresh rate is low making focusing and camera adjustments more difficult and time consuming.
- Use consumer grade sensors (even if they are CCD) so some bad pixel locations are considered acceptable. This becomes a major issue if use of image analysis software is anticipated.
- Poor low light performance with limited spectral response. The cameras are designed to be used in typical consumer camera applications and mostly have filters to block most non-visible light.
- Difficult to use with 3rd party image analysis software since they don't have native drivers available.
- Much more prone to THEFT. Chargers and accessories are always available elsewhere so having the camera body is all that is necessary.
- Models become obsoleted quickly so long term support is not assured.

Summary

The scientific camera is a more rugged, user friendly way to capture and utilize images. Much less time and frustration will be spent in acquiring good images…TIME IS MONEY in business.

<u>CCD vs. CMOS CAMERA SENSORS</u>

Advances in camera sensor technology continue to change rapidly but this summary of strengths and weaknesses still appears valid in understanding imaging camera choices.

CCD:

<u>Strengths</u>

- Highest image quality
- Lowest noise factor
- Better output uniformity
- Superior quantum efficiency and noise performance
- ALL of the pixel surface area can be devoted to light capture
- Excellent low light capture (highest sensitivity)

<u>Weaknesses</u>

- More costly to manufacture
- Require off-chip support circuits for sensor conversion

<u>Best Applications</u>

- Low light photography (Darkfield, DIC, fluorescence, Hoffman Modulation)
- Critical imaging applications using advanced image analysis software

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CMOS:

<u>Strengths</u>

- Low cost to manufacture and purchase
- Can have support circuits on-chip for each pixel for more compact camera designs
    - But at the expense of reduced pixel surface area for capture
- Requires less ‘off-chip’ circuitry

<u>Weaknesses</u>

- Poor low light performance (especially critical issue for microscopy)
- Poorer image uniformity of light since each pixel has its own charge to voltage converter.
- Higher noise factor (especially critical in fluorescence applications)
- Requires an on-chip ‘microlense’ to increase pixel well fill since some of surface area is used by conversion circuitry
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<u>Best Applications</u>

- Medium light photography (Brightfield, phase contrast)
- Cost critical applications