INTERFERENCE PATTERN IN SPECTRAL CAMERA PFD

1 Background

1.1 CCD detectors

Some CCD detectors may introduce fringes or interference pattern seen in the image. This is often called **spectral fringing or etaloning**. When that happens reflections between the nearly parallel front and back surfaces of these devices cause them to act as etalons. This etalon-like behavior leads to unwanted fringes of contructive and destructive interference which artificially modulate the spectrum [1].

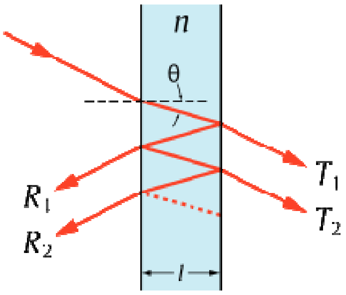

Figure 1. Diagram of an etalon [2]

Etaloning is related to back-illuminated CCDs. In those etaloning is seen in the near infrared above 700 nm. **Front-illuminated CCDs do not suffer from etaloning** because the detector structure is different.

1.2 CMOS detectors

CMOS detectors a photodiode devices. They are nowadays replacing CCDs in many applications due lower cost and smaller dimensions. The design typically consists of either inter-metal dielectric (IMD) layers or inter-layer dielectric (ILD) layers. Those are used to separate and electrically isolate wiring lines and other conductors in semiconductor devices. When making these devices smaller and smaller there can be multiple layers causing total thickness to become thicker than before. **Thick dielectric material above the sensor region of the CMOS sensor causes interference when light passes through the dielectric material into the sensor region** and decreases the sensitivity of the CMOS sensor [3].

There are some methods including different layer material and structure or different coating to reduce the interference effect, but many of these have side effects in a form of performance.

2 Spectral Camera PFD

2.1 Interference pattern

Specim Spectral Camera PFD has a CMOS detector. This camera has an interference pattern discussed in chapter 1.2. It should not be confused with etaloning. In figure 2 below is spectral profile of a data acquiring using halogen light source as an illumination. Intererference pattern is clearly visible.

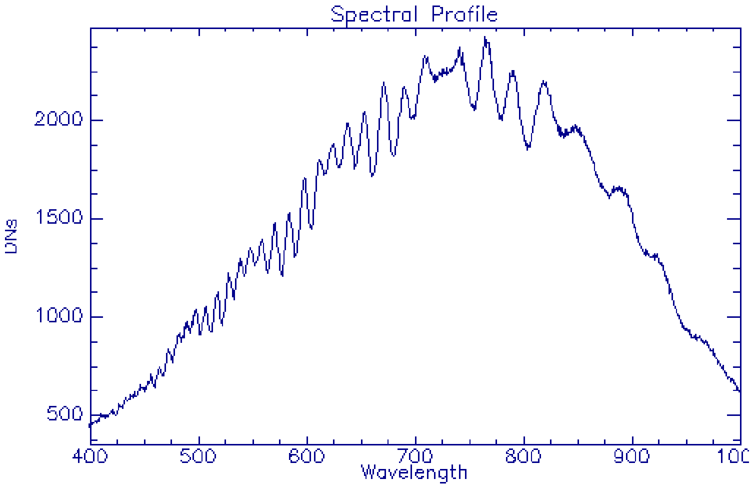

Figure 2. Typical spectral profile for Spectral Camera PFD.

According to camera manufacturer the interference is caused by reflections in the CMOS detector metal layers 1 to 4. On top of these layers there is also AR (anti-reflective) coating (Si3N4). This coating absorbs below 450 nm. The purpose of the coating is to reduce internal reflections and thus stray light, which would appear as excess signal in your data distorting the results.

How strong the interference is depends for example on geometry, illumination bandwidth and temperature. You do not see the interference in a normal 2D imaging application, but the pattern appears when you attach the camera with a spectrograph using very narrow bands that are typical for spectral imaging.

2.2 Correction methods

There are two methods than can be used to correct or at least minimize the effect of interference. The first method is **radiometric correction**. When the system radiometric calibration and application of radiometric correction are performed under similar conditions to pattern should disappear in radiometrically corrected data. The second method is **normalization** using white and dark references. White reference must cover whole field of view. Reflectance estimate R = (Image – Dark) / (White – Dark) will have either no or very minimal interference pattern left in the image.

What makes things a bit complicated is that interference pattern changes to some extent with the temperature. We do not have any detailed information available on that, but have experienced that proposed correction methods do not fully correct the issue under all conditions.

3 References

1. Roper Scientific. http://www.roperscientific.de/etaloning.html
2. Etalon. https://en.wiktionary.org/wiki/etalon
3. Jui-Hsiang Pan. Method for avoiding interference in a CMOS sensors. Patent US 6043115A.