

# blooming – anti-blooming

If light impinges on a spot of a CCD-image sensor, the individual "well" (pixel) is filled up with the generated charge carriers. When there is too much light, the well capacity is exceeded, and the additional charges spill into the adjacent "wells" (pixels). This undesirable phenomenon is called blooming, which results in inaccurate data in neighboring pixels, ultimately reducing spatial resolution. Anti-blooming measures are defined as any actions taken to reduce this effect.

with blooming



without blooming



The image with blooming illustrates a light emitting diode chip generating blooming because of the high light level. The second image (without blooming), shows the sharp image of an LED chip where anti-blooming measures were taken.

## blooming reduction & prevention options

### in applications

- ➔ reduction of the light signal
- ➔ masking or changing the image area
- ➔ if high light levels within the image are necessary, and the information needed is in the lower light or value range, changing to a system with higher effective dynamics can be helpful (e.g., from 8 bit (0-256 counts) to 12 bit (0-4096 counts) or from 12 bit to 14 bit (0-16384 counts)).

### for CCD image sensor manufacturing

- ➔ horizontal anti-blooming - an anti-blooming gate electrode is implemented beside the pixel (horizontally). With appropriate timing, the generated charge carriers will no longer spill into the neighboring pixel. However, they can be depleted by the anti-blooming drain generated by the gate electrode.
  - advantage: simple structure, high efficiency
  - disadvantage: uses some space on the light sensitive pixel

# blooming – anti-blooming

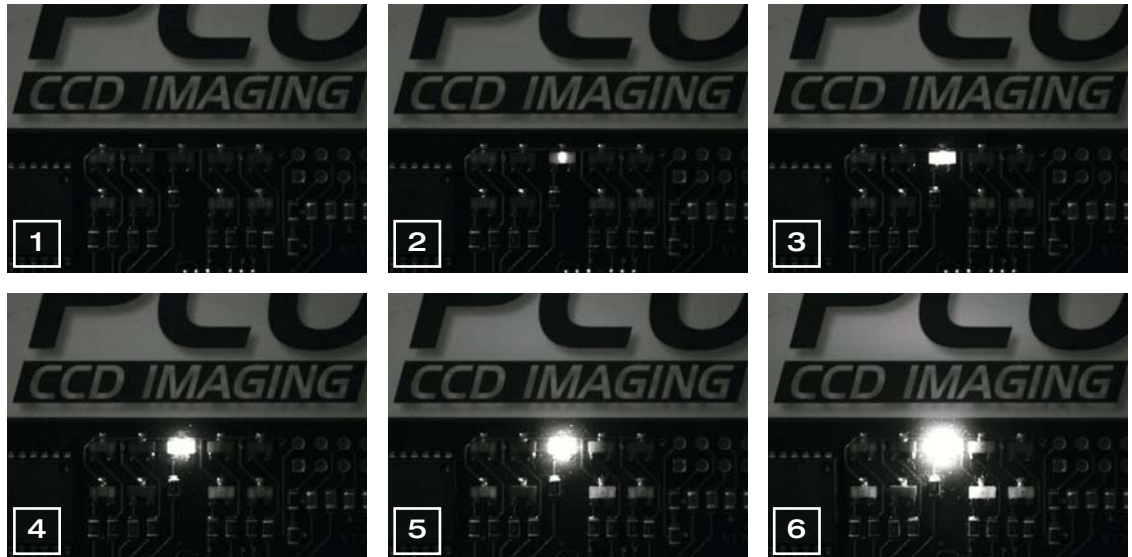
➔ Clocked anti-blooming - to prevent the generated electrons from spilling into neighboring pixels, the recombination of charge carriers is utilized, where the charge carriers are combined with oppositely charged "holes" before they reach the next "well". Continuous clocking allows the supply of "holes" to be refreshed (e.g., during line feed, HSYNC).

Current CCD image sensors can tolerate 50 to 100 times over-exposure without blooming.

- advantage: light sensitive space on the image sensor is not used
- disadvantage: complex timing with three different clock levels are needed; reduces full well capacity

➔ Vertical anti-blooming - Similar to horizontal anti-blooming, additional anti-blooming structures below the light sensitive pixels (vertically) are integrated. Vertical anti-blooming structures can be implemented into all types of CCD, however they can be complex and difficult to optimize.

- advantage:
  - anti-blooming structure is compact and does not require use of light sensitive space on the image sensor
  - high efficiency with 104 times overexposure
  - reduced dark current
  - total modulation transfer function (MTF) is improved as free diffusion of the charge carriers is limited (diffusion MTF)
- disadvantage:
  - more difficult to optimize the CCD image sensor
  - because of the complexity of the structure: effective penetration depth for radiation into the silica is reduced, decreasing the red and infrared sensitivity



The series of images above were taken using a constant exposure and maximum scaling (0-4095 counts => 0-255 grey values) to illustrate the influence of the light signal on blooming. From image to image, the LED chip's light level is increased and generates blooming (Note that blooming begins in image 4).