

### “Nyquist sampling criterion”

In digital signal processing (DSP), frequency of signal sampling must be at least twice faster than the highest signal frequency components to accurately reconstruct the information. In digital imaging, sampling frequency is limited by the pixel size of the chip, and Nyquist theorem requires that the diffraction-limited Airy disk projected on the image sensor must be larger than two pixels of the chip size. If this criterion is not satisfied, unnatural, erroneous pattern may be generated. This phenomenon is broadly called “**aliasing**” and the pattern is sometimes called “**moire pattern**” because of resemblance. Aliasing can be removed by algorithm (antialiasing filter, such as low pass filter), but this process also removes potentially important information.

(Example) Using an 100x/N.A. 1.4 objective and N.A. 1.2 condenser lens with a monochromatic green light (546 nm) illumination, the Abbe limit of resolution ( $d$ ) is 252 nm (equation-1). The image is magnified 100 times by the objective, producing 25,200 nm image (equation-2). On the CCD chip, the image must be large enough to cover two pixels, i.e., 12,600 nm (equation-3). Therefore, the pixel size of the sensor must be 12,600 nm or smaller to accurately reproduce the signal.

$$\text{(equation-1) } d = \lambda / (\text{NA}_{\text{obj}} + \text{NA}_{\text{cond}}) = 252 \text{ nm}$$

$$\text{(equation-2) } 252 \text{ nm} \times 100 = 25,200 \text{ nm}$$

$$\text{(equation-3) } 25,200 / 2 = 12,600 \text{ nm}$$