

Microscopy

Problem Set 2

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Based on the Advanced Optical Imaging Workshop Plymouth
given by Noah Russell, 2018

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Please hand in the solutions of this problem set next lecture on May 3rd of 2019.

2 Your first illumination system

In the last Problem Set you were asked to sketch a Köhler illumination system. In this task you will analyze in more detail how this system works.

- a) **Direct illumination.** Let's start with the most intuitive way to illuminate a sample: placing the light source (Figure 1), in this case a light-emitting diode (LED) close to the sample.

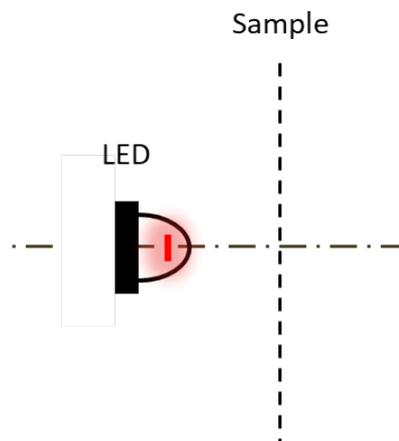


Figure 1: Direct illumination

- (i) Indicate all the light rays coming from the LED and indicate the rays that reach the sample.
- (ii) **Explain** the disadvantages of this system.

- b) **Critical illumination.** In order to improve the illumination, a critical illumination system is inserted. This creates an image of the light source in the sample plane. To do so, a 4f system is inserted (Figure 2).

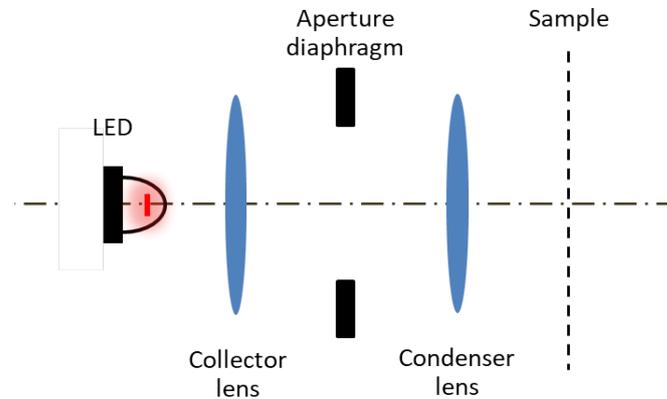


Figure 2: Critical illumination

- (i) Considering an infinity corrected system, indicate the distances between the LED and the collector lens, the collector lens and the aperture diaphragm, and the aperture diaphragm and the sample. Consider $f_{collector} = f_{condenser} = 25mm$.
 - (ii) Draw the chief and marginal rays coming from an on-axis point of the LED.
 - (iii) **Explain** what happens in the sample when the aperture is closed down? Hint: Describe how it changes the numerical aperture of the illumination in the sample.
 - (iv) **Explain** what is the disadvantage of imaging the LED filament onto the sample?
- c) **Köhler illumination.** To overcome the previous issues, a field lens ($f_{field} = 75mm$) is placed (Figure 3). Therefore, the image of the LED will not appear in the sample but in the aperture diaphragm. And the rays coming from this image will be collimated by the condenser lens.

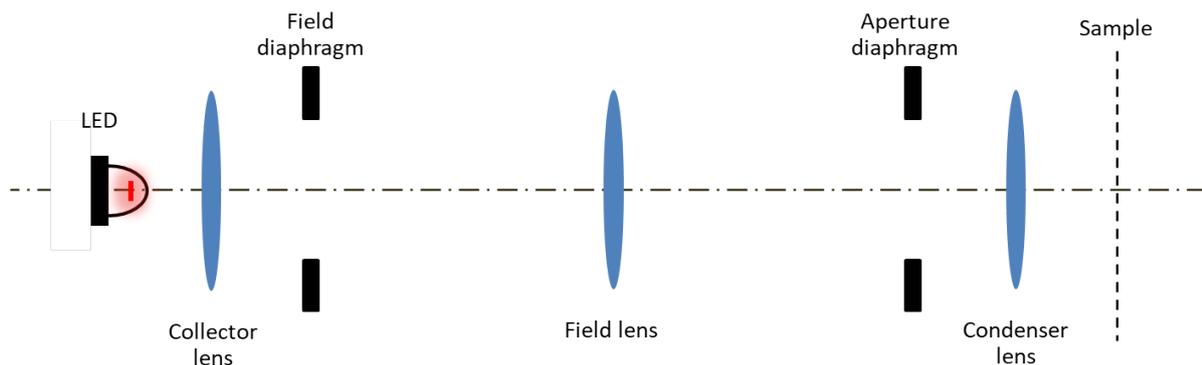


Figure 3: Köhler illumination

- (i) Indicate the distances between all the components to have an infinity corrected system.
- (ii) Draw the chief and marginal rays coming from an on-axis point of the LED.
- (iii) **Explain** what happens in the sample when the field diaphragm is closed down?
- (iv) Draw 2 parallel rays coming from the most external part of the LED.
- (v) **Explain** what happens in the sample when the aperture diaphragm is closed down?