

Microscope Objectives

TYPES OF OBJECTIVES

Objectives are classified into groups depending on how well they are corrected for the dominant aberrations: chromatic aberration (color), spherical aberration, and field curvature. The simplest objectives (achromats) are corrected for color in the red and blue and for spherical aberration in the green. More complex objectives (apochromats) are color corrected in the red, yellow, and blue and corrected for spherical aberration at two to three different wavelengths. For applications that require good image quality across a wide FOV, "plan" objectives (plan achromats and plan apochromats) are also corrected for field curvature. Plan objectives generally have longer working distances than simple designs.

Each objective is designed to be used with a specific type of microscope. Biological objectives are corrected to view the object through a glass coverslip. If a biological objective, particularly one with a large NA, is used without a coverslip, the image will not be sharp. Similarly, non-biological objectives will not function optimally if there is glass between the objective and the object.

Older microscope objectives (before 1980) were designed to form an image at a given distance (the tube length) behind the objective flange. This distance varied between 160 mm and 210 mm depending on the manufacturer and the application. At the proper tube length, the objectives formed images at their nominal magnifications. Modern microscope objects are "infinity corrected." They are optimized to provide collimated light on their image side. A separate decollimating or tube lens then forms the image. This design gives microscope manufacturers flexibility to insert lighting and beamsplitters in the collimated space behind the objective. The proper focal length tube lens is required to form an image at the objective nominal magnification.

Many special-purpose objectives are available. Some are color corrected for wavelengths in the infrared or ultraviolet regions. Low-fluorescence objectives are available for ultraviolet fluorescence applications. Strain-free objectives are used for applications where the polarization of the image light must be maintained.

CHOOSING AN OBJECTIVE

The most important parameter for choosing a microscope objective is its NA. The larger the NA, the higher the resolving power, which means that the objective can distinguish closely spaced features from each other. The NA is related to the magnification; a higher magnification objective usually has a larger NA. The objective provides its specified magnification when used in a microscope with the proper tube length, or with the proper decollimating lens. The objective can also be used at different magnifications; the specified magnification provides an approximate guide. Both NA and magnification are usually printed on the barrel of the objective. An objective with a larger NA gathers more light but provides a smaller DOF, shorter working distance, and higher cost than an objective with a smaller NA. Because these tradeoffs are crucial to the success of the application, the objective NA must be chosen carefully.

The FOV is the sensor size divided by the magnification. The magnification (and FOV) can be adjusted by changing tube length or the focal length of the decollimating lens. Using a magnification greatly different from the one printed on the objective generally results in a poorly optimized system.

Microscope objectives have a small working distance (WD), the distance from the tip of the objective barrel to the object. This is a problem in machine vision, where there are often fixtures that must fit between the objective and the object. For those applications, there are objectives with longer working distance, called LWD or ELWD lenses. These objectives are larger and more expensive than standard objectives.

There are several different and incompatible standards for microscope mounting threads (DIN, JIS, RMS, and others). It is usually not possible to adapt from one thread to another. Within a single family, objectives are usually "parfocal", which means the distance from the objective mounting flange to the object is the same for each objective in the family. On a microscope, this means the the objective (and magnification) can be switched without a large refocus motion.