11 Common Breadboarding Mistakes

AND HOW TO AVOID THEM

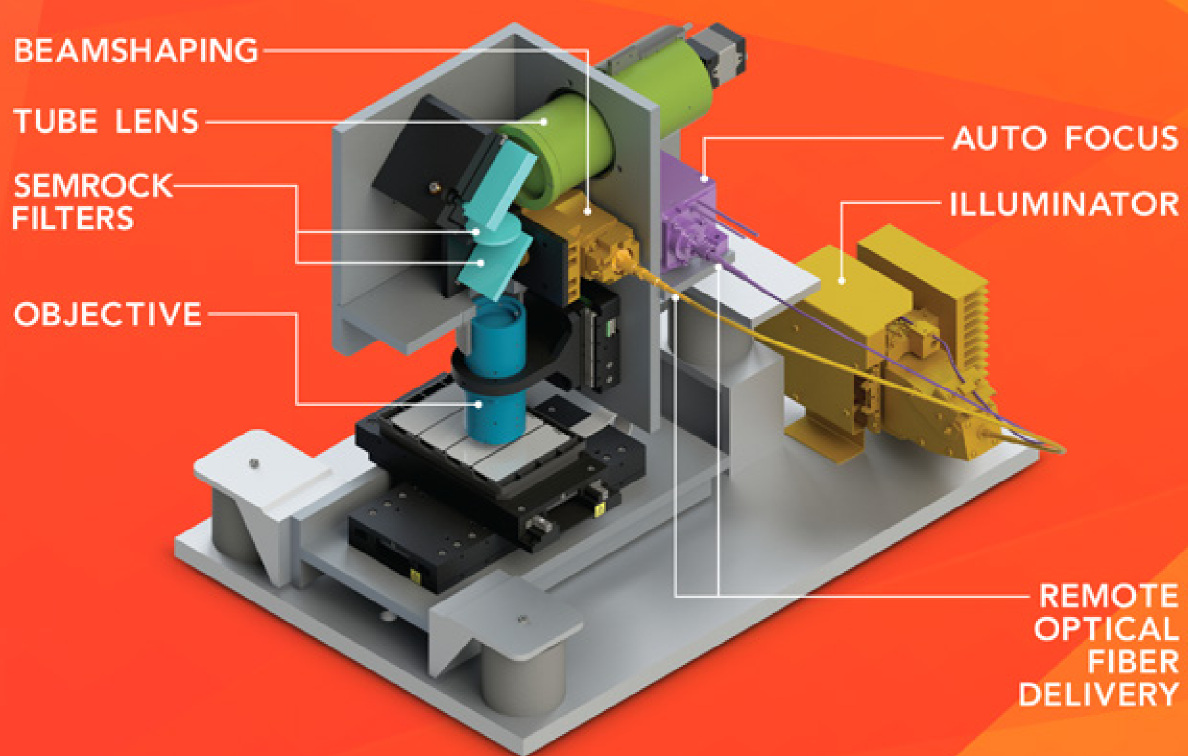
IDEX HEALTH & SCIENCE | MELLES GRIOT

11 Common Breadboarding Mistakes and How to Avoid Them

Creating a breadboard microscope system can be a valuable tool, whether the goal is to test out new technology or architecture, or to capture data on a new sample preparation.

A breadboard microscope can provide a customizable setup for researchers and product developers alike.

Building a breadboard can be a challenging endeavor, particularly when working to integrate high-performance optical components. Improper execution at the breadboard phase can lead to bad data quality, delays, costly overruns, and poor product development decisions. This guide highlights some of the common mistakes made during the breadboard phase and how they can be avoided.

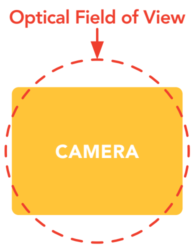


MISTAKE 1

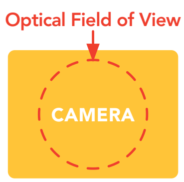
Not Matching Optics to the Sensor

The Problem

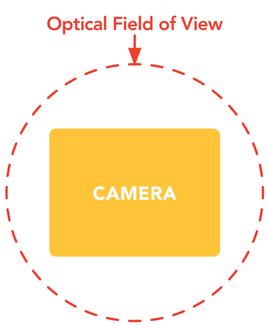
Incompatibility between the imaging optics and sensor leads to sub-optimal microscope performance. Overfilling the sensor wastes valuable optical performance, while underfilling sacrifices potential sensor throughput.



Example of well-matched optics and camera



Example of poorly-matched optics and camera (pixels wasted)



Example of poorly-matched optics and camera (optical field of view wasted)

Additionally, sensor pixel pitch should be well-matched to the optical resolution to ensure sufficient sampling of the focused spot.

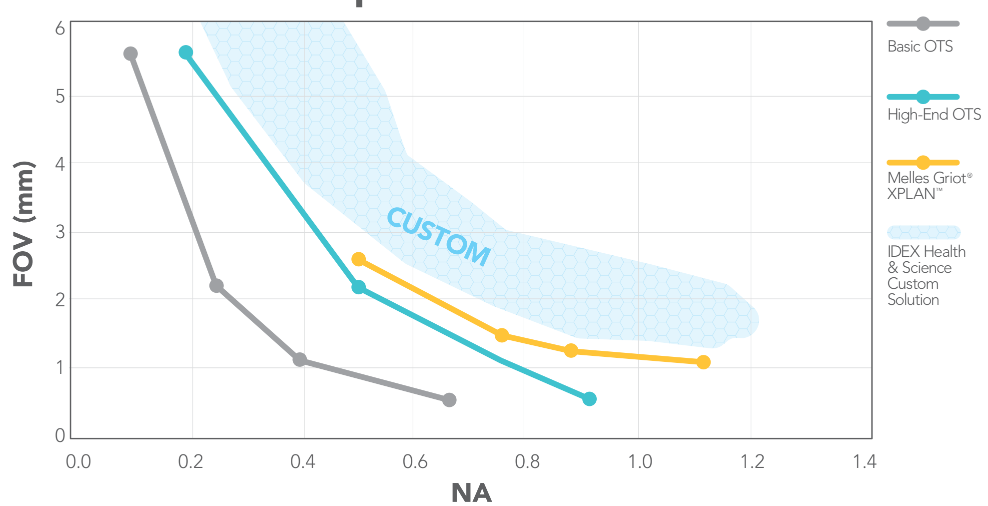
The Solution

Choose imaging optics and sensors that match sensor size to the optical field of view, and pixel pitch to the optical resolution.

How IDEX Health & Science Can Help

Using the **Melles Griot® XPLAN™ CCG Lens Series** from our Breadboarding Toolkit can resolve this mismatch. They are engineered with magnification and NA combinations specifically optimized for the large-format sensors and small pixel pitches common in high-throughput life science applications.

NA vs. FOV Map



MISTAKE 2

Skipping the Autofocus Module

The Problem

Image-based autofocus routines introduce a significant time delay to find focus. This can lead to loss of throughput and, in fluorescence applications, photobleaching of the sample.

The Solution

Utilize a dedicated autofocus module to maintain focus in real-time.

How IDEX Health & Science Can Help

Our **Melles Griot® Laser Autofocus Module** is designed for accurate focus tracking, keeping the objective in focus and image quality optimal. Future versions will include high-speed refresh rate, expanding its capabilities to applications with high-speed sample translation.

MISTAKE 3

Failure to Match the Objective to the Cover Glass

The Problem

A mismatch of the objective to the cover glass can severely degrade image quality, especially at higher NA. This error can introduce significant spherical aberration that scales with the square of the Numerical Aperture. At very high NA, even the cover glass tolerance can impact image quality if not well-controlled.

The Solution

Ensure the objective is optimized for the intended cover glass thickness and material, or that it can compensate for varying thicknesses to maintain diffraction-limited performance.

How IDEX Health & Science Can Help

Our **Melles Griot® XPLAN™ CCG lenses** can be adjusted in the factory to fit your cover glass needs and deliver crystal-clear images.

MISTAKE 4

Designing Imaging Optics without Considering Filter Requirements

The Problem

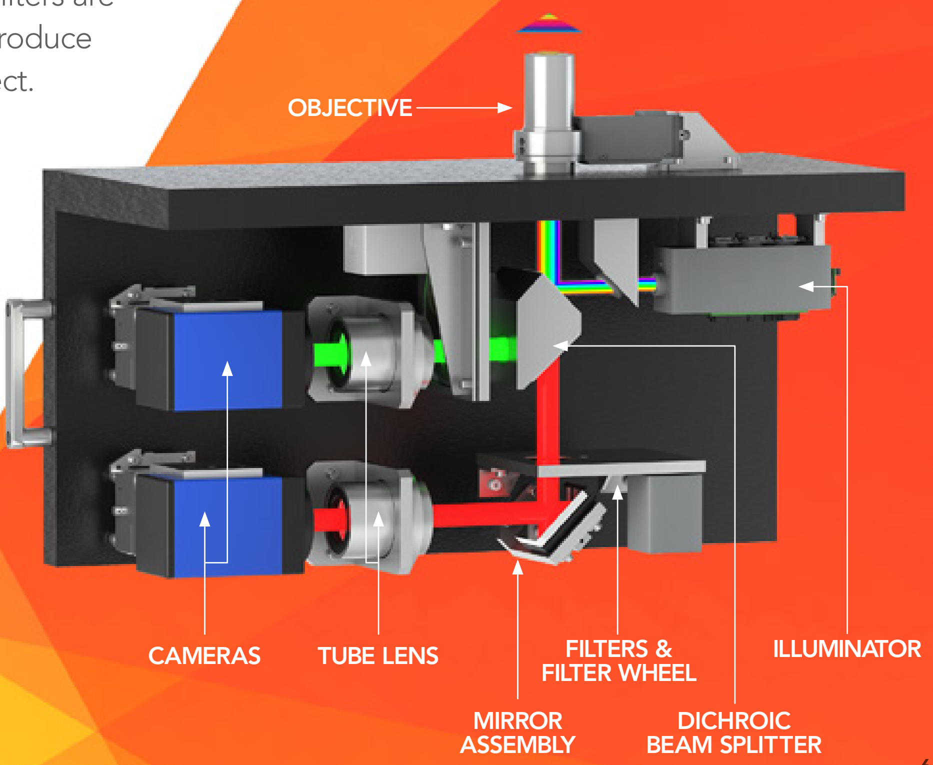
Treating filter requirements as an afterthought when designing the imaging optics can result in over-constrained filter specifications. If filter requirements are ignored until the optical design is finalized, you may find yourself forced into custom, high-complexity coating specifications. These non-standard filters are significantly more expensive and introduce long lead times that can stall a project.

The Solution

Model the optical path and spectral requirements in parallel. By designing these components together, you can ensure that appropriate design choices are made to achieve your system specifications while minimizing filter cost and lead time.

How IDEX Health & Science Can Help

Our IDEX Health & Science engineers have many years of experience designing filters and optics in parallel to ensure maximum performance and manufacturability.



MISTAKE 5

Verifying Optical Performance

The Problem

Many catalog objectives do not come with proof of optical performance. This can make system design very difficult, as the margin required to ensure system optical performance is achieved is unknown. Additionally, there can be significant variation in performance between different objectives.

The Solution

Require serialized verification data to confirm that each component meets the required specifications.

How IDEX Health & Science Can Help

Every objective in our **XPLAN™ CCG Series** is individually tested in conjunction with our dedicated tube lenses. We provide these detailed test reports to our customers, allowing you to integrate with known performance data rather than relying on nominal estimates. By default, IDEX Health & Science verifies wavefront performance, but additional performance parameters can be characterized by request.

Melles Griot®
XPLAN™ CCG
Lens Series

MISTAKE 6

Image Quality in the Field

The Problem

Many OTS objectives suffer from drastically reduced optical quality in the field. Others use vignetting to reduce field aberrations, resulting in dark corners with lower SNR and non-uniform data across the sensor.

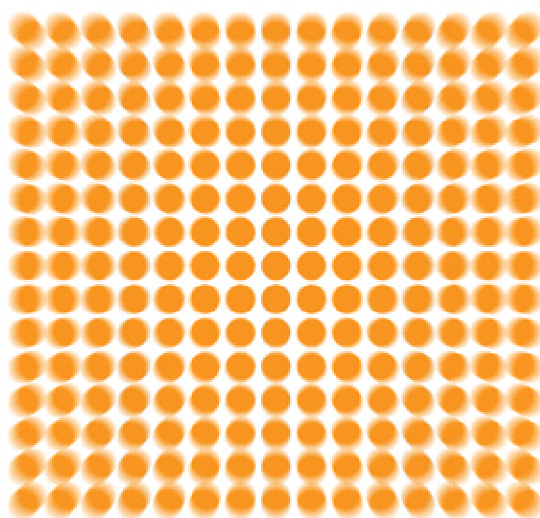
The Solution

Select lenses engineered for edge-to-edge diffraction-limited performance and zero vignetting across the full field of view.

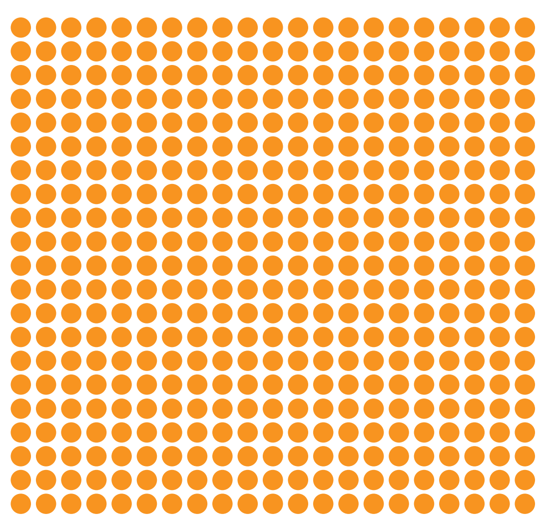
How IDEX Health & Science Can Help

Our **XPLAN™ series optics** are designed and tested for high-performance imaging across the field of view, with no vignetting.

LARGE FIELD OF VIEW



Current Solution



Melles Griot® XPLAN™ CCG Lens Series

MISTAKE 7

Choosing the Right Optomechanics

The Problem

The optical mounts must be rigid enough to hold optical assemblies in alignment over time. Furthermore, lacking the appropriate degrees of freedom can lead to poor optical alignment and reduced data quality.

The Solution

Prioritize high-stability mounting with independent tip/tilt adjustments to ensure the optical system can be optimally aligned.

MISTAKE 8

Alignment Strategy

The Problem

High-quality components are only as effective as their alignment. This becomes especially critical for high NA and/or large field of view objectives, such as the **XPLAN™**, where sample or camera alignment errors can significantly reduce data quality.

The Solution

Use precision mechanical datums or adjustable mounts with an alignment procedure that optimizes critical alignments. In particular, objective to tube lens, illumination to objective, and camera to optical axis alignments can make-or-break image quality.

How IDEX Health & Science Can Help

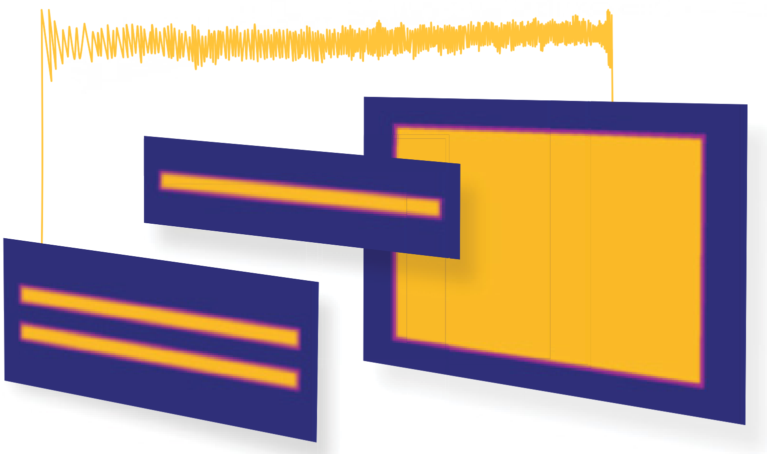
The **XPLAN™ series optics** are designed with looser alignment tolerances to simplify objective to tube lens alignment and ensure optimal image quality without cumbersome alignment procedures.

MISTAKE 9

Illumination: Beam Shaping and Wavelength Choice

The Problem

Without careful design of illumination optics, the sample can experience uneven excitation. Proper beam shaping matched to the objective and sensor architecture is required to ensure a flat-top profile and maximize photon budget and imaging area. Correct wavelength choice and filter selection are also critical to ensure that stray light is minimized and the desired signal is maximized.



The Solution

Implement beam shaping optics to generate a uniform profile at the sample and choose filters that are optimized for the excitation wavelength and intended fluorescence bands.

How IDEX Health & Science Can Help

Utilizing **Melles Griot® Laser Engines** and beam shaping optics will deliver a uniform, high irradiance excitation to your sample, ensuring high SNR across the field of view.

Water Immersion: To Use or Not to Use?

The Problem

Deciding between air and water immersion is a first-order design choice that fundamentally alters system performance and usability. While water immersion enables higher resolution and is inherently less sensitive to cover glass thickness variations, it introduces significant challenges of its own. Maintaining the integrity of the water interface — avoiding bubbles and evaporation — over long imaging runs requires careful consideration.

The Solution

Evaluate the specific resolution requirements of your optical system to determine if water immersion is required. If the application demands the highest possible NA, the system must be engineered to support a stable water interface from day one.

How IDEX Health & Science Can Help

We provide options for both paths. **Our XPLAN™ CCG Series** includes three high-performance air objectives with large fields of view and one dedicated water immersion objective for applications requiring maximum resolution. We consult on these trade-offs to ensure your choice aligns with both your optical needs and your final instrument's complexity.

MISTAKE 11

Failure to Consider Packaging Requirements for a Product

The Problem

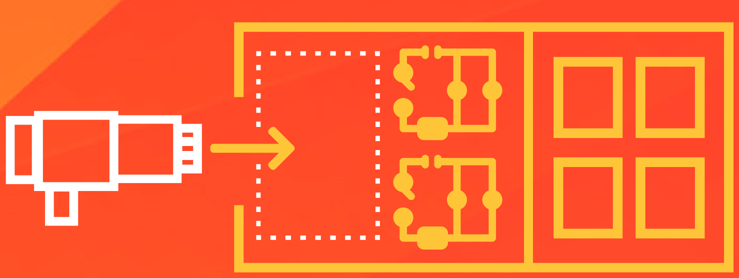
Large, commercially available optical tables can easily be procured, allowing for very little consideration of packaging constraints during a breadboard phase. However, commercial instruments are often required to fit on a standard lab bench or within a compact chassis. A common roadblock to commercialization is a benchtop prototype that relies on a sprawling, free-space layout that simply cannot be "shrunk" without a total optomechanical redesign.

The Solution

For breadboard systems that are intended to easily progress to a product, evaluate your final instrument's packaging requirements during the breadboard design. Consider how packaging requirements will influence the optical design, folding architecture, and illumination delivery. Delivering the illumination via an optical fiber can significantly reduce the illumination footprint within the optical system.

How IDEX Health & Science Can Help

Our team of experts can help you determine the optimal system architecture for your packaging goals. By leveraging **Melles Griot® Laser Engines** within our Breadboarding Toolkit, you can utilize fiber delivery to relocate the laser source away from the primary imaging path. This flexibility allows you to tuck the laser engine into an available corner of the instrument housing, preserving the compact footprint required for a marketable, benchtop product.



Leveraging Vertical Integration for System Success

Transitioning an optical system from a benchtop prototype to a commercial-grade instrument requires a unified integration strategy. By partnering with Melles Griot Optical Systems from IDEX Health & Science, you gain access to a vertically integrated ecosystem where lasers, thin-film filters, and precision imaging optics are engineered to function as a singular, optimized assembly.

This vertically integrated approach, supported by our expert engineering teams, removes the compatibility issues and finger-pointing that can occur when sourcing from disparate vendors, ensuring that your path to manufacture is predictable, repeatable, and scalable.

Ready to Stabilize Your Optical Path?

Tell us about your project and let our engineers help you navigate the transition from breadboard to build.

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