

Abstract

High-power laser excitation systems are critical in observing and studying nanomaterials and their optoelectronic properties on a single specie level. These systems enable inducing fluorescence and observing emission microscopically from individual flakes and or molecules. As the fluorescence of nanomaterials is often excitation dependent, multiple laser with different frequencies are needed to probe their optical properties. In this work we construct such multi-laser setup to use for a microscopy system to enable imaging nanocarbons: flakes of functional derivatives of graphene, carbon nanotubes, and graphene quantum dots.

The system is composed of four lasers of varying wavelength: blue at 450 nm, green at 532 nm, red at 637 nm, and near-infrared (NIR) at 808 nm. An additional near-infrared laser at 980 nm is included for special applications with deep NIR imaging. These lasers were set up to be turned on and off remotely and traverse through a system of dichroic and regular mirrors and a periscope coupled to a fluorescence microscope. A neutral density filter wheel designed and set up in the light path enables altering the intensity of the lasers leading to optimized fluorescence and imaging. The resulting laser set up allowed effective imaging of graphene oxide flakes, graphene quantum dots, and carbon nanotubes (CNTs) both on a microscope slide and in biological cells and tissues.

Components of System

The system consists of four primary lasers with an additional laser that can be used via a flip mirror for specific deep NIR applications:

- 450 nm Blue laser
- 532 nm Green laser
- 637 nm Red laser
- 808 nm NIR laser
- 980 nm Deep NIR laser (not pictured)

Four Dichroic Mirrors (DMs) that allow certain wavelengths to pass while other are reflected:

- Blue DM
 - **Reflects Green**
- Green DM
 - Reflects Red
 - Allows Green to Pass
- Yellow DM
 - Reflects Blue
 - Allows Green and Red to Pass
- Transparent DM
 - Reflects IR
 - Allows Visible to Pass

Periscope with mirrors for directing beam towards microscope Boards with black foil for shielding

Two-sided Neutral Density Filter (NDs) wheel which reduces intensity without polarizing the beam:

- Side 1: Blank, 0.2, 0.3, 0.4, 0.5, 4.0
- Side 2: Blank, 0.6, 1.0, 2.0, 3.0, 4.0





Construction and Implementation of a High-Powered Multi-Laser Excitation System

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Laser System in Operation









Images Taken Using System



(7,5) CNTs with emission at 1030 nm





(7,6) CNTs with emission at 1130 nm

Summary

• The system is capable of using multiple lasers at the wavelengths of 450 nm, 532 nm, 637 nm, 808 nm, and 980 nm in various combinations via remote control

Intensity can be altered via ND filters

• The system enables optimized excitation for various materials

• The system is capable of fluorescence microscopy for graphene oxide flakes, graphene quantum dots, and CNTs in both slides and biological cells.

Hep G2 cell with (7,5) CNTs in red, (7,6)CNTs in blue, and PX-866 in green