MAT 288S Optoelectronic Measurements

Spring 2010

Laboratory 1: Spot Size, fiber coupling, and spectral radiance

Safety Note: The tungsten-halogen lamp emits ultraviolet (UV) radiation. Always wear plastic safety glasses or UV-blocking prescription glasses when the lamp is on. If you are adjusting components in the beam, wear gloves and long sleeves to protect your hands and arms. Do not gaze at the lamp, or a focused image of it. Likewise, do not look directly at the beam from the Helium Neon laser, and take care to avoid sending reflections of the laser beam toward others. It is bright enough to cause permanent eye damage.

Introduction

It is a common need to couple light into an optical fiber, in order to conveniently illuminate a monochromator or sample. In some cases, the fiber must be single mode to maintain high spectral resolution or small spot size at the sample. Your goal in this lab is to maximize the light coupled into a single mode fiber, within a specified spectral range. Your light source will be a small tungsten halogen lamp in combination with a narrow band interference filter. For comparison, you will also use a helium neon laser. You will also calculate the spectral radiance of these two light sources, and compare your experimental values to the expected values.

Please report your results, explaining your design philosophy, the measured spot size at the fiber input, the power per unit optical bandwidth that you coupled into the fiber, the coupling efficiency between the source and the fiber, and the calculated source spectral radiance. Discuss quantitatively how your results compare to what you expected. Limit your report to two pages, with embedded, legible figures, as in *Electronics Letters*.

Resources

Lamp: You will use a 20W Quartz Tungsten Halogen (QTH) lamp operating from a standard DC power supply. Do not exceed 6.0 Volts on the QTH lamp: the minimal

increase in intensity is accompanied by a very dramatic reduction in lifetime. The lamp gets hot. Do not position anything other than glass components close to it.

Examine the **spare** QTH lamp filament under the inspection microscope located at the cleaving station in ESB 3309. Consider the filament size, and whether you wish to image the entire filament, or a portion of it, onto the end of the fiber.

Laser: You will also use a Helium Neon laser operating at 633 nm, for comparison. The beam diameter at the laser output is 0.48 mm, and the beam divergence angle is 1.7 mrad.

Lenses: A variety of uncoated and antireflection coated singlets and achromats are available for your use. The achromats are designed and coated for the NIR, but should perform adequately at 633 nm. Many of the lenses are marked in pencil on the edge; those that are unmarked should be checked for focal length, because the labeling on the bag is unreliable. In addition, there are various microscope objectives available, optimized in the visible, but also commonly used in the NIR.

Singlets and achromats

Part number	Type	Diameter (mm)	Focal length (mm)
LAC 896-C	Achromat	25.4	30.0
LAC 127-C	Achromat	25.4	40.0
LAC 382-C	Achromat	25.4	50.0
LAC 684-C	Achromat	50.8	75.0
LAC 227-C	Achromat	50.8	100.0
LA 1951	Singlet	25.4	25.4
LA 1131	Singlet	25.4	50.0
LA 1509	Singlet	25.4	100.0
LA 1145	Singlet	50.8	75.0
LA 1050	Singlet	50.8	100.0
LA 1417	Singlet	50.8	150.0

Objective lenses

Mag / NA	Clear aperture (mm)	Working distance (mm)
2.5/0/07	6	42
4/0.12	6	24
5/0.12	6	13
10/0/25	6	7
10/0.3	6	7
15/?	5	11
20/0.4	4	7
20/0.4 Nikon	7	3
30/0.6	4	1
40/0.65	3	0.6
50/0.45 B&L (high quality)	7	5

Filter: Use the 25 mm diameter interference filter, 03 FIL 024, with peak transmission of >50% at 633 nm, and a FWHM bandwidth of 10 nm.

Power meter: The UDT optical power meter has an uncalibrated silicon detector, so make all measurements recording just photocurrent, not optical power. There is also a fiber coupling attachment and filter holder, should you choose to use them.

Optical fiber: Use the brown-cabled optical fiber. It has a step-index profile, with a 5.6 micron mode diameter at 830 nm, and a numerical aperture of 0.12. The fiber is not single mode at 633 nm, but it is close. Examine the fiber face under the inspection microscope: when the other end is held under the illuminator, you will see the fiber core light up. Clean the ceramic ferrule using alcohol and gentle wiping with a clean Q-tip.

Pinholes and slits: There is an air slit of variable width, and mounted pinholes of various diameters. Treat these gently, as they are easily damaged.

Miscellaneous hardware: There are lens holders, translation stages, and optical breadboard components on the optical bench. Please remember to use flat washers underneath all screws, to avoid gouging the aluminum mounting bases. Thumbscrews should be tightened by hand only.

A word of caution about the large lens holders: the top sliding mount contains a spring-loaded plunger to hold the lenses tight. Do not release the side screw without first placing the mount on its side, on a clean room towel, or the lens will fall out and shatter when the plunger suddenly lets go.

Tips:

1. Insure that the optical components are colinear, to avoid image broadening due to optical coma. It is helpful to use a ruler to insure that the beam propagates parallel to the bench, and along a line of holes.
2. Insure that the lenses and the face of the fiber are perpendicular to the incident beam.
3. Always wear clean gloves when handling lenses, for finger oil is very difficult to remove. Use canned air to blow dust from lenses. They do not need to be spotless: attenuation is only proportional to the fraction of the glass covered by the dust particles. The less cleaning, the better. Never use anything but clean methanol to clean these lenses. Note that other lenses may have coatings that require other solvents.