doric

Fiber Optic Light Propagation Depending of Tip

Application Note

Version 1.0.0

Contents

1

Introduction

The following simulations give an overview of the light propagation into brain tissue for different optical fibers, with different tips and light sources.

For the comparison, we used a 200 µm core diameter with three different optical fiber types:

- Silica core, doped silica clad, NA0.22
- Doped silica core, doped silica clad, NA0.37
- High index borosilicate core, low-index borosilicate clad, NA0.66

We compare light output and propagation into brain tissue for various fiber tip shapes (see Fig. 1.1):

- Flat
- Angle 45° and 60°
- Cone
- 45° Mirror
- Tapered

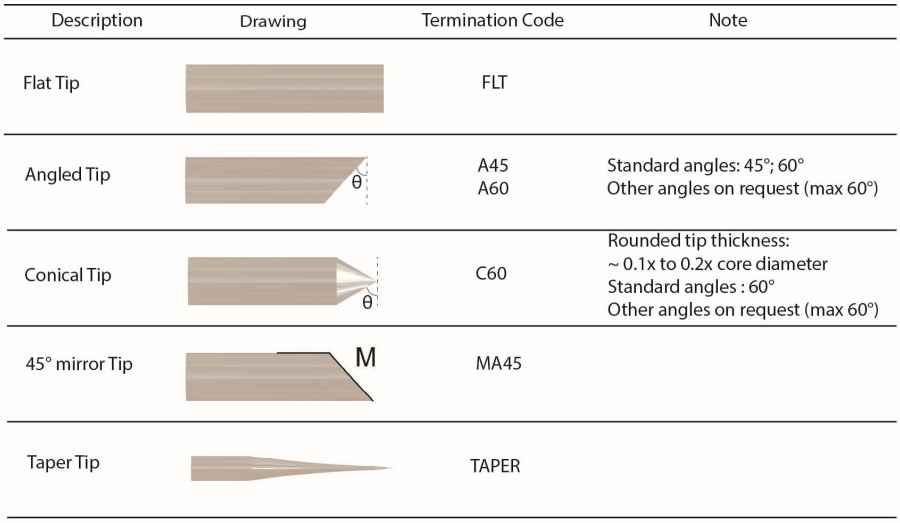


Figure 1.1: *Cannula Tip*

And we wanted to demonstrate the effect of light injection with a source that overfills the optical fiber NA such as a LED, compared to a laser that will be typically injected with an effective NA below 0.22 and is less affected by the optical fiber NA.

To carry out the simulations, various parameters are defined in Zemax. Gray matter diffuser parameters are shown below:

Model	DLL Defined Scattering
Mean Path	0.089
Angle	180
DLL	Henyey-Greenstein-bulk.DLL
Transmission	0.5
Anisotropy parameter g	0.96

We use a scattering model utilizing the Henyey-Greenstein phase function as follows:

$$p\cos(\theta) = \frac{1-g^2}{2(1+g^2-2gcos(\theta))^{3/2}} \tag{1.1}$$

where g is the anisotropy parameter, between 0 (no anisotropy) and 1 (pure forward scatter).

Figure 1.2 shows a simulation result example. It is a cross-section of the light propagation into gray matter at the output of a 200 µm core diameter, silica optical fiber with NA of 0.22 having a flat tip termination, and where 5 mW of light was injected with NA 0.15 to simulate a laser source. The profile below shows the on-axis decay of the intensity with the propagation distance.

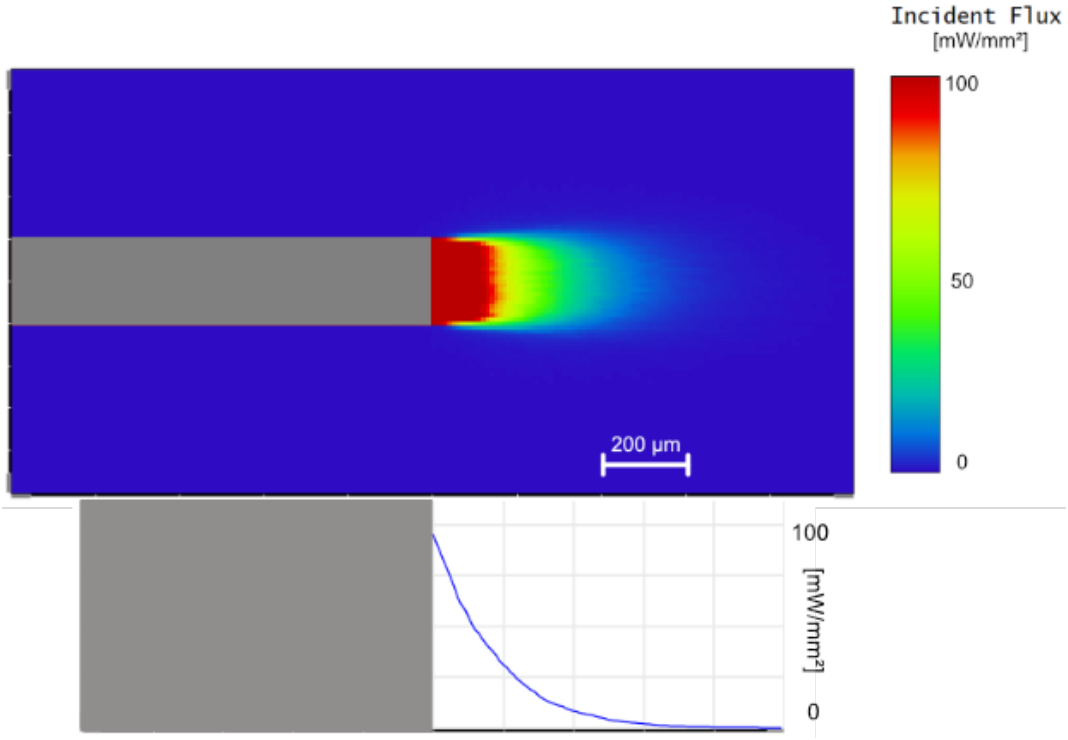
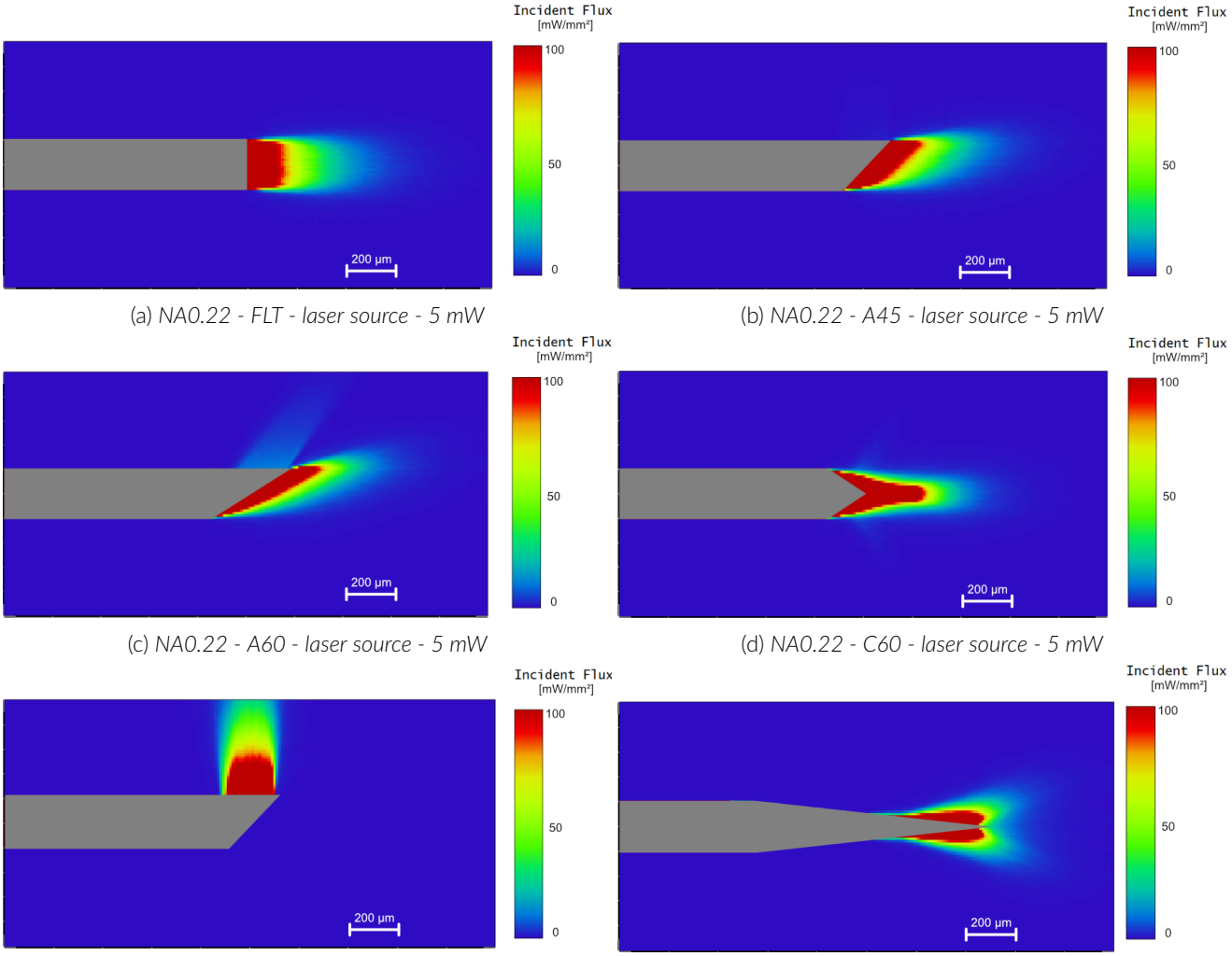


Figure 1.2: *MFC 200/220-0.22-FLT - laser NA0.15 with 5mW input*

Multiple simulations of the light propagation at the optical fiber output are presented in this application notes to help compare different optical fiber, light source, and fiber tip terminations.

2

Fiber 200µm vs. Different Optical Fiber Tips



(a) *NA0.22 - FLT - laser source - 5 mW*

(b) *NA0.22 - A45 - laser source - 5 mW*

(c) *NA0.22 - A60 - laser source - 5 mW*

(d) *NA0.22 - C60 - laser source - 5 mW*

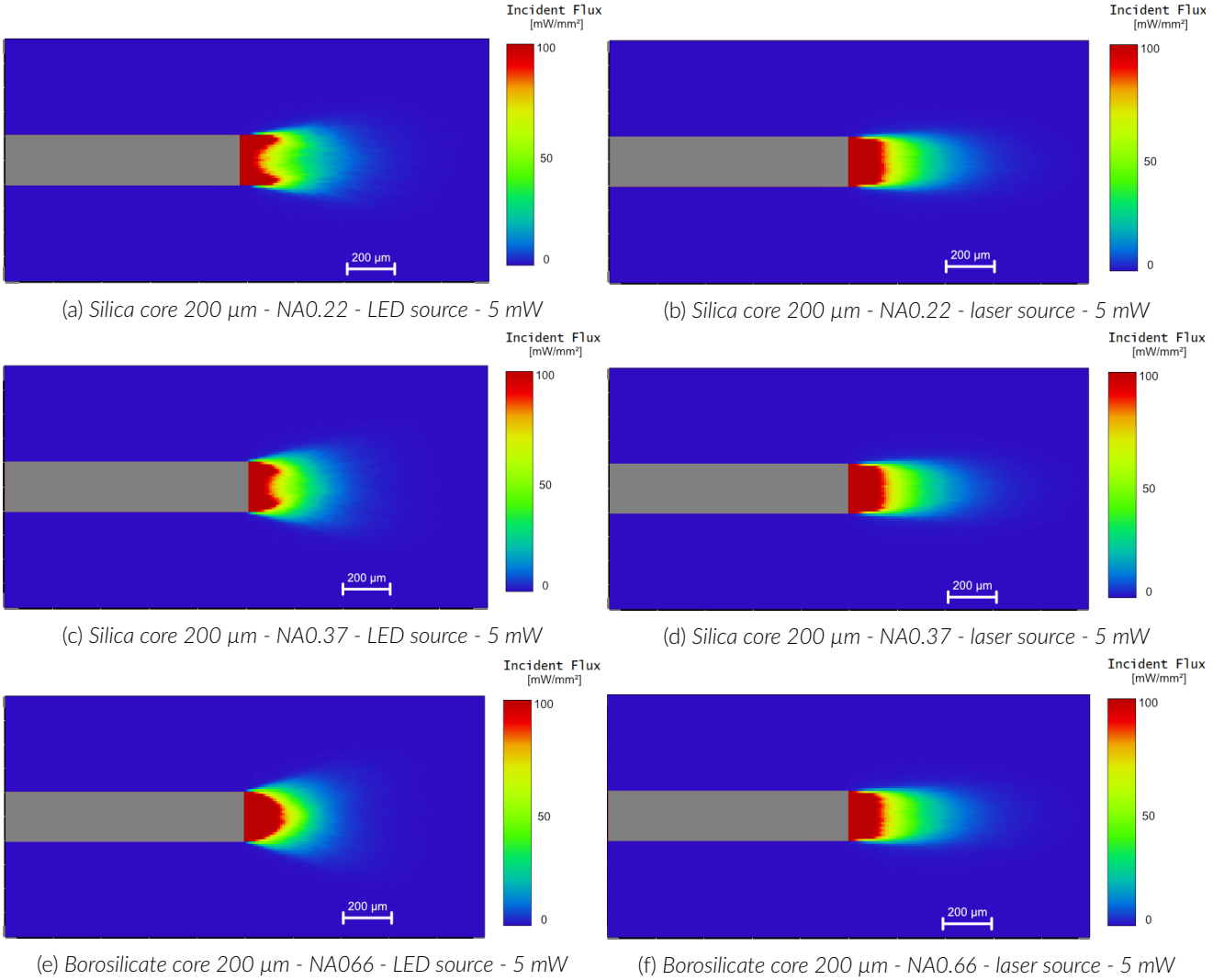
(e) *NA0.22 - MA45 - laser source - 5 mW*

(f) *NA0.22 - TP1.0mm - laser source - 5 mW*

Figure 2.1: *Silica Core 200 µm Optical Fiber*

3

Flat Tip (FLT) vs. Different Optical Fibers



(a) *Silica core 200 µm - NA0.22 - LED source - 5 mW*

(b) *Silica core 200 µm - NA0.22 - laser source - 5 mW*

(c) *Silica core 200 µm - NA0.37 - LED source - 5 mW*

(d) *Silica core 200 µm - NA0.37 - laser source - 5 mW*

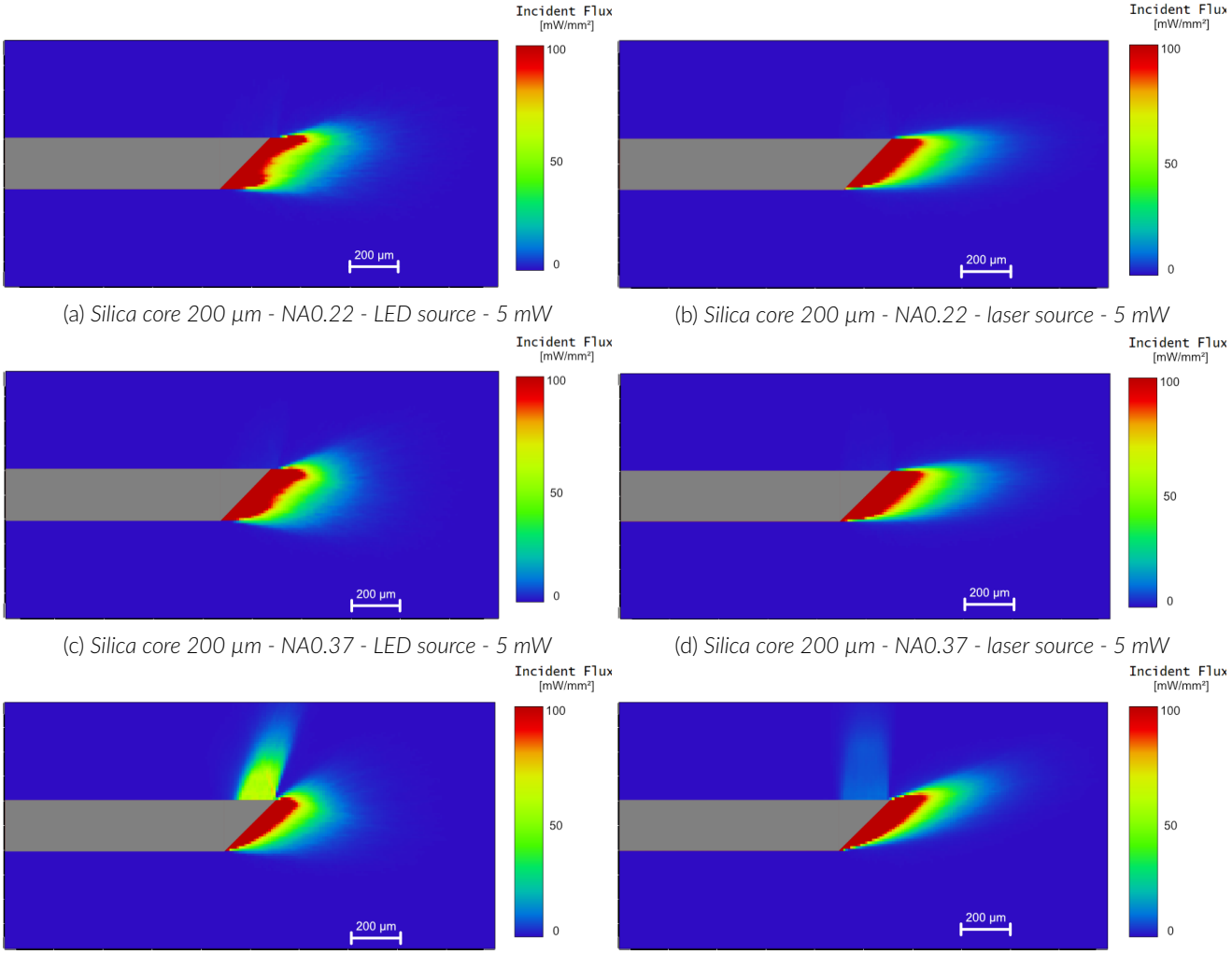
(e) *Borosilicate core 200 µm - NA066 - LED source - 5 mW*

(f) *Borosilicate core 200 µm - NA0.66 - laser source - 5 mW*

Figure 3.1: *Flat Tip (FLT) Fiber Termination*

4

Angle Tip (A45) vs. Different Optical Fibers



(a) *Silica core 200 µm - NA0.22 - LED source - 5 mW*

(b) *Silica core 200 µm - NA0.22 - laser source - 5 mW*

(c) *Silica core 200 µm - NA0.37 - LED source - 5 mW*

(d) *Silica core 200 µm - NA0.37 - laser source - 5 mW*

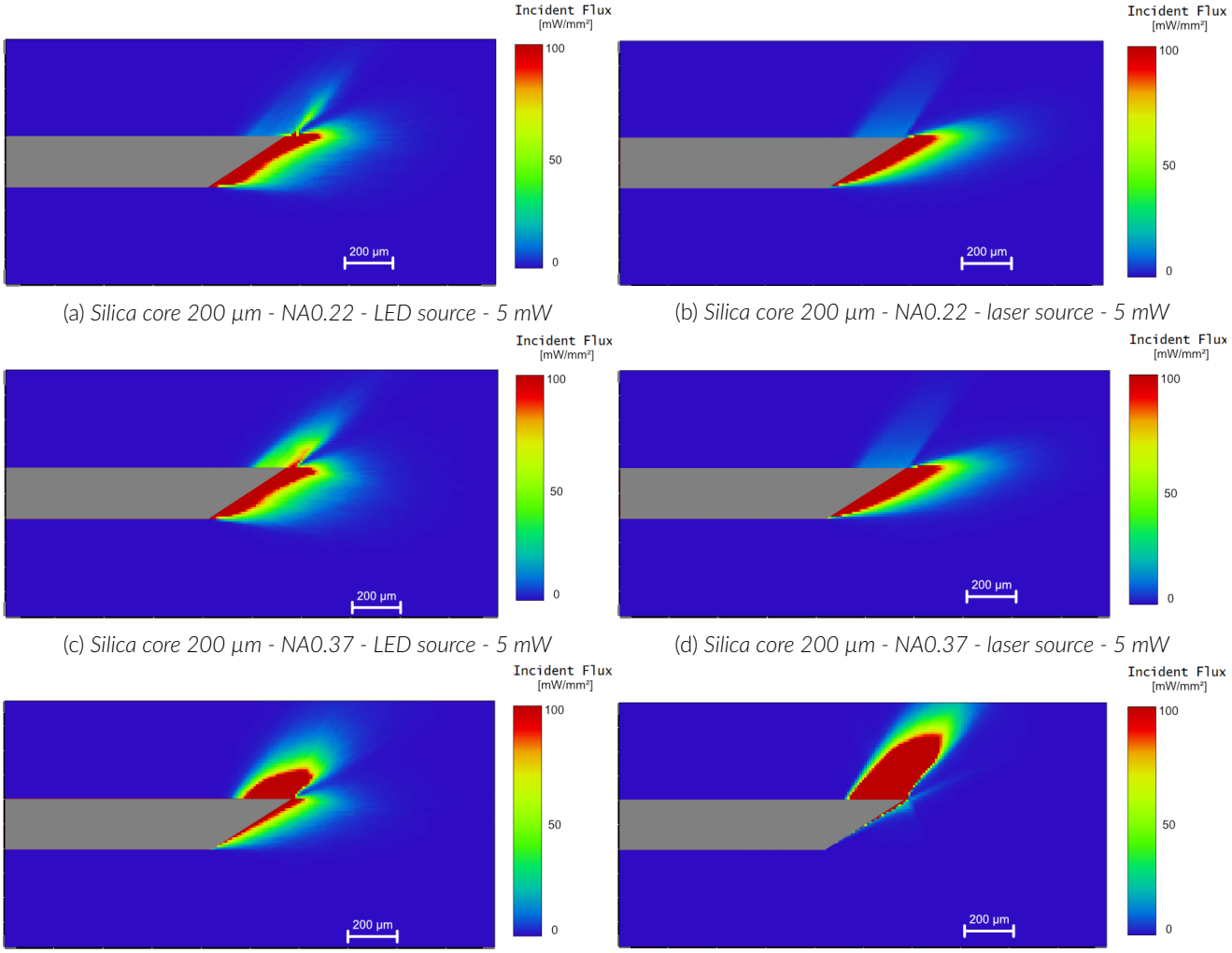
(e) *Borosilicate core 200 µm - NA0.66 - LED source - 5 mW*

(f) *Borosilicate core 200 µm - NA0.66 - laser source - 5 mW*

Figure 4.1: *Angle Tip 45° (A45) Fiber Termination*

5

Angle Tip (A60) vs. Different Optical Fibers



(a) *Silica core 200 µm - NA0.22 - LED source - 5 mW*

(b) *Silica core 200 µm - NA0.22 - laser source - 5 mW*

(c) *Silica core 200 µm - NA0.37 - LED source - 5 mW*

(d) *Silica core 200 µm - NA0.37 - laser source - 5 mW*

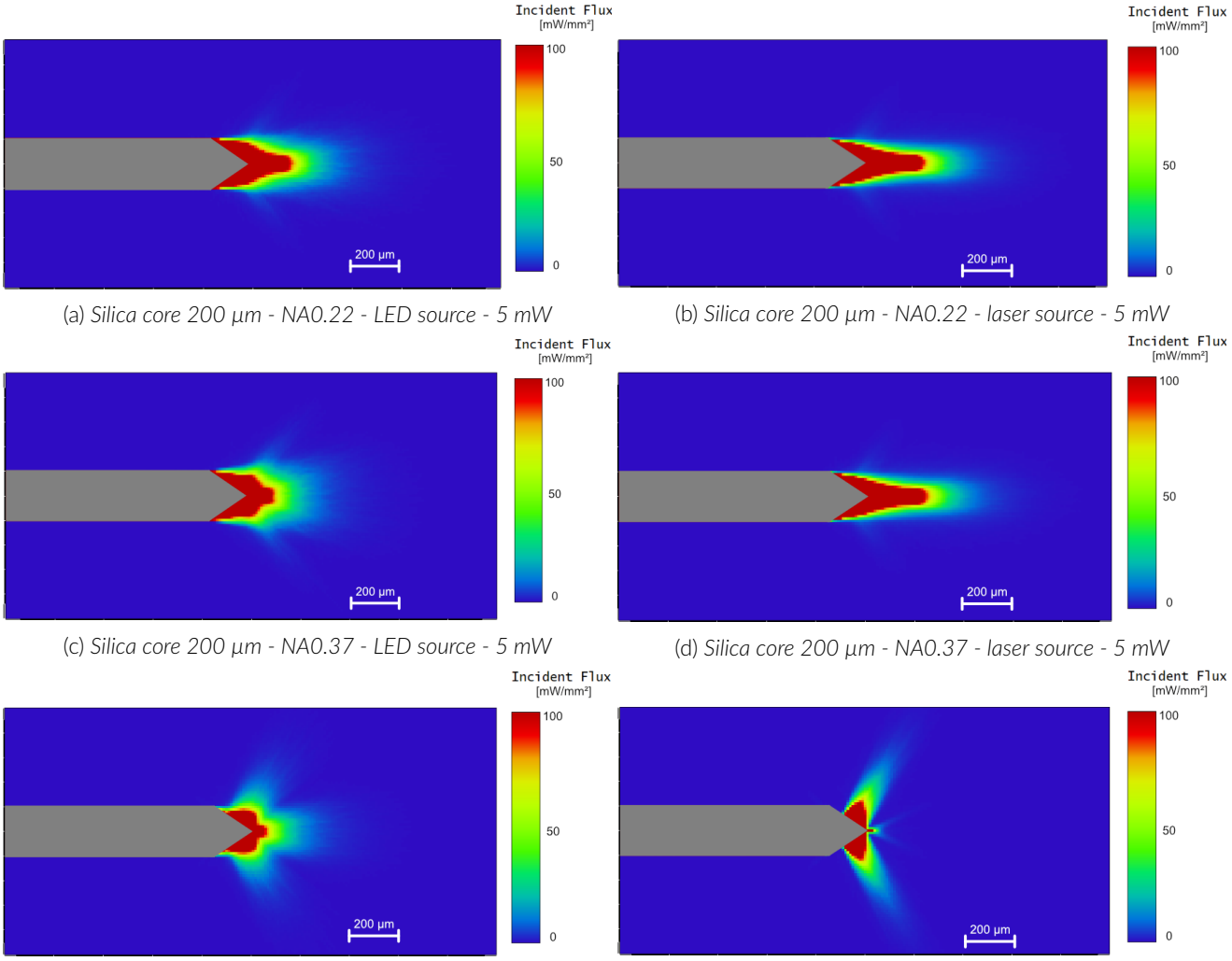
(e) *Borosilicate core 200 µm - NA0.66 - LED source - 5 mW*

(f) *Borosilicate core 200 µm - NA0.66 - laser source - 5 mW*

Figure 5.1: *Angle Tip 60° (A60) Fiber Termination*

6

Cone Tip (C60) vs. Different Optical Fibers



(a) *Silica core 200 µm - NA0.22 - LED source - 5 mW*

(b) *Silica core 200 µm - NA0.22 - laser source - 5 mW*

(c) *Silica core 200 µm - NA0.37 - LED source - 5 mW*

(d) *Silica core 200 µm - NA0.37 - laser source - 5 mW*

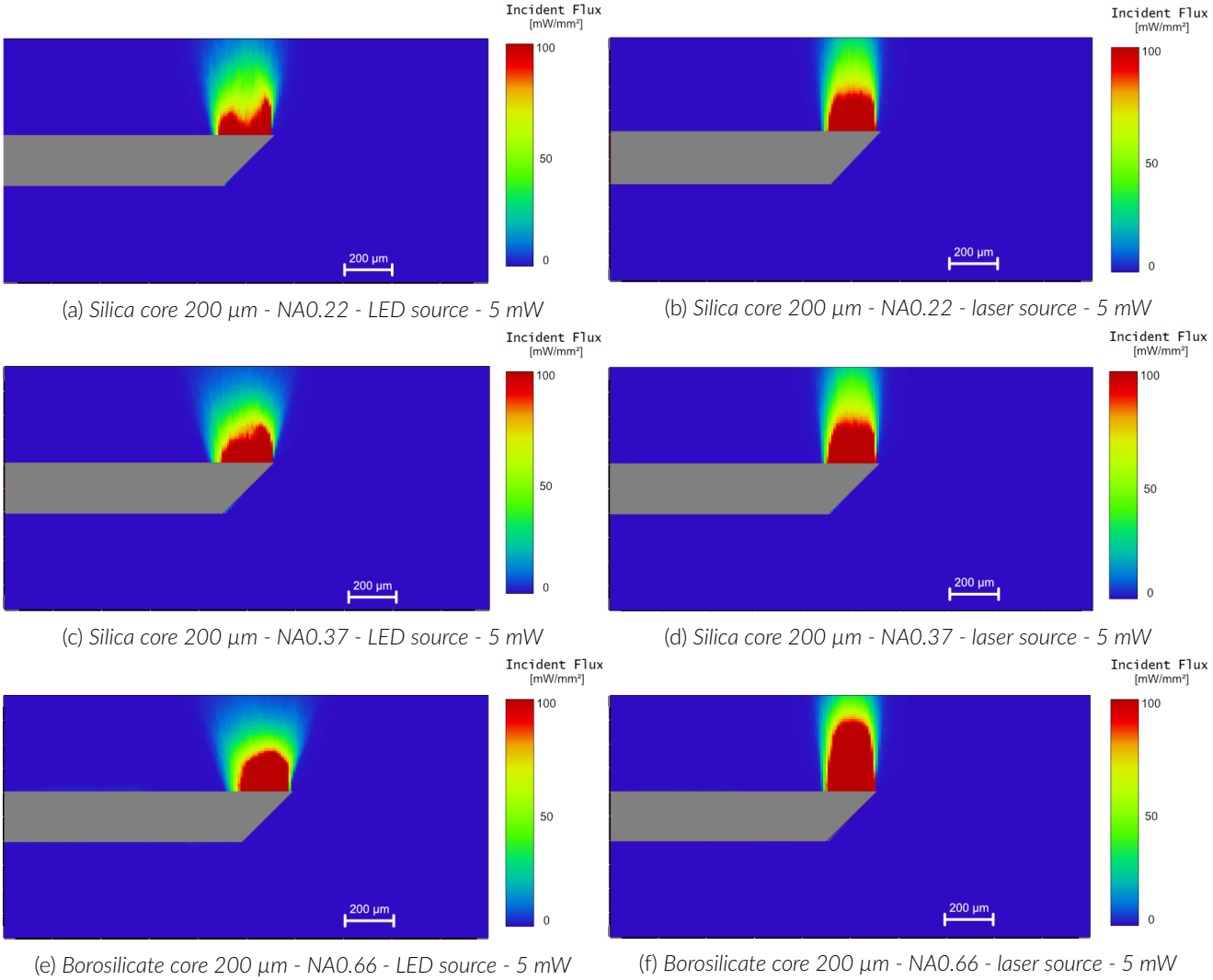
(e) *Borosilicate core 200 µm - NA0.66 - LED source - 5 mW*

(f) *Borosilicate core 200 µm - NA0.66 - laser source - 5 mW*

Figure 6.1: *Cone Tip 60° (A60) Fiber Termination*

7

Mirror Tip (MA45) vs. Different Optical Fibers



(a) *Silica core 200 µm - NA0.22 - LED source - 5 mW*

(b) *Silica core 200 µm - NA0.22 - laser source - 5 mW*

(c) *Silica core 200 µm - NA0.37 - LED source - 5 mW*

(d) *Silica core 200 µm - NA0.37 - laser source - 5 mW*

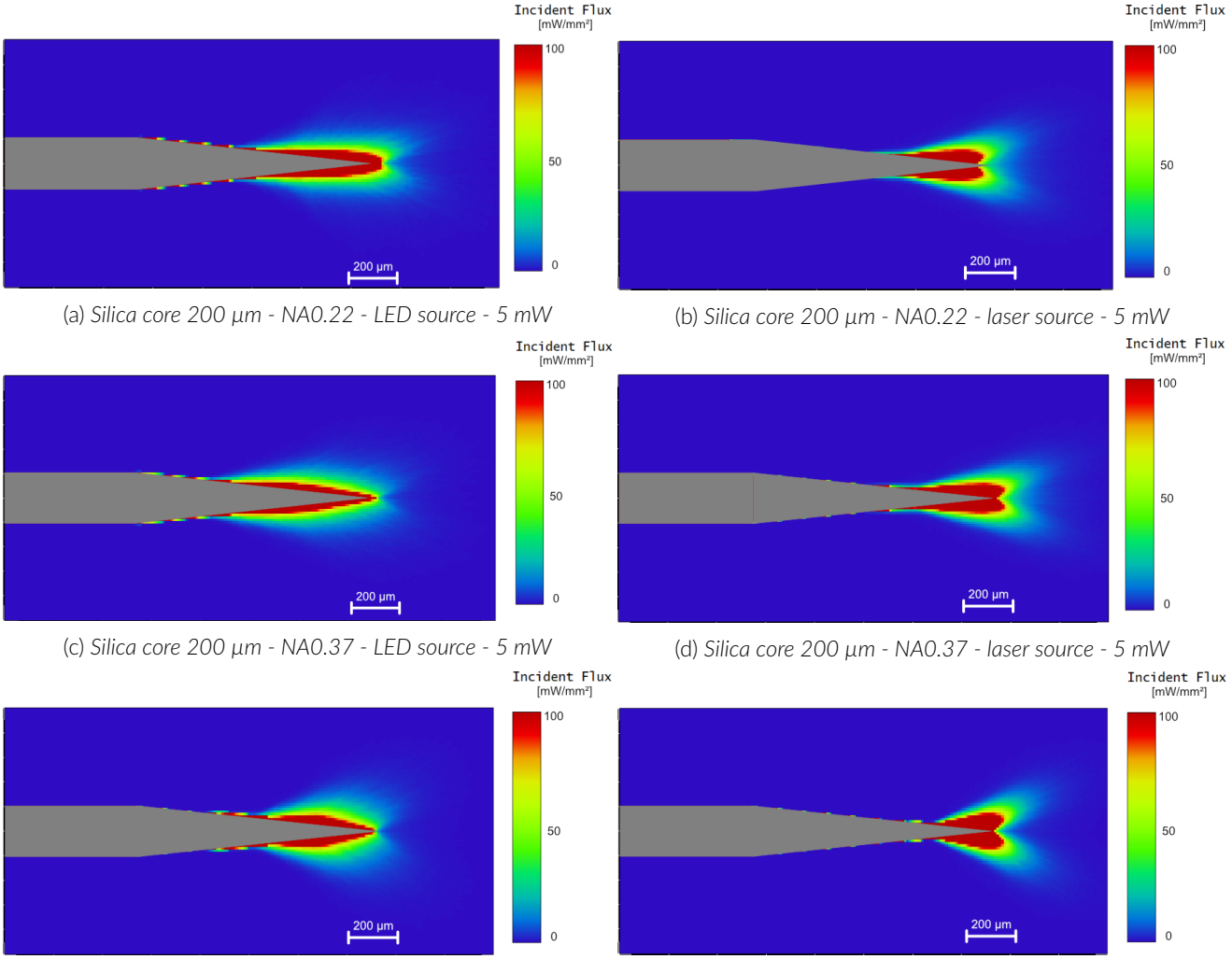
(e) *Borosilicate core 200 µm - NA0.66 - LED source - 5 mW*

(f) *Borosilicate core 200 µm - NA0.66 - laser source - 5 mW*

Figure 7.1: *Mirror Tip (MA45) Fiber Termination*

8

Tapered Tip (TP1.0) vs. Different Optical Fibers



(a) *Silica core 200 µm - NA0.22 - LED source - 5 mW*

(b) *Silica core 200 µm - NA0.22 - laser source - 5 mW*

(c) *Silica core 200 µm - NA0.37 - LED source - 5 mW*

(d) *Silica core 200 µm - NA0.37 - laser source - 5 mW*

(e) *Borosilicate core 200 µm - NA0.66 - LED source - 5 mW*

(f) *Borosilicate core 200 µm - NA0.66 - laser source - 5 mW*

Figure 8.1: *Tapered Tip (TP1.0) Fiber Termination*