# Cookbook for 3D printing waveguides using Asiga Pico 3D printer

## Printing

The printer receives print jobs from the “Asiga Composer” program, which in turn accepts the STL file format (both text and binary). To print, open the program; select your printer and layer thickness and then “Add parts”.

## Model

The printer is not able to print on a substrate or change printing material at a specified layer, and therefore to minimize light loss into the substrate the waveguides must be raised on thin supports. Each waveguide should be a single printing layer, to avoid aliasing between the layers and loss due to layer interfaces.

The substrate needs to be at least 3 mm thick, otherwise it will bend when taken off the build platform. This makes printing with a base plate unnecessary, as well as auto generated supports (see “[print setting](#_Print_settings)”).

In the interest of printing thin waveguides, the thinnest recommended setting is waveguides 100 microns high by 200 microns wide. This gives sufficient surface area for the guides to hold to the supports. These should be printed with 100 micron layers, and the waveguide should fill one layer (and not be split among two, for the reasons mentioned above).

Thinner waveguides (such as 50x100 and 75x150 microns) have considerably rougher surfaces, leading to increased losses (to the point of 99% loss over 1 cm). Surface roughness can be reduced by careful cleaning (in “[cleaning](#_Removing_print_from)” section), to a point where the losses in the 200x100 micron waveguides are acceptable.

The supports for the waveguides should be 3 layers tall (i.e. 300 microns for recommended settings) and at least 3 times the width of the wave guide (one width on each side), to avoid them falling apart during printing. Shorter supports will not provide bridging (the waveguides will be connected to the substrate the whole way). To accommodate these settings, exposure time needs to be extended (see “[print setting](#_Print_settings)”).

There should be mo more than 1 support per mm, otherwise bridging doesn’t occur. Using fewer supports seems to lead to increased loss of light along the guide (to the air). The supports should be perpendicular to the waveguides wherever possible – otherwise the waveguides come off and bend out of shape.

Additionally, The ends of the waveguides will need to be cut (as they come out very rough after printing), so all wave guide should extend 200-300 microns beyond the place they should reach, to allow for laser cutting to smooth them (see “[Laser cutting](#_Laser_cutting_the)”). Leaving more than 300 microns extra results in the fiber breaking off. Broken ends have better light insertion than unbroken ends and ends that have been cut with a knife, but not as good as end that are cut with laser.

## Print settings

In “Asiga Composer”, Place your pieces in the build area (using “Add parts” and “Auto place”), then press print.

On the first screen press “next” (no setting to change). The program will warn you that your pieces (that should include their own substrate, see “[Model](#_Model)”) do not have supports and may fall. Use “Auto-place” to move everything to 0.00 base height (under “z-leveling”) and ignore this warning (press “continue”).

On the next screen, set “base plate thickness” to 0 and “Erosion” to 0. Press “next”.

Under “Advanced Parameters”, set “Separation Velocity” and “Approach Velocity” to 5 mm/s, “Normal Wait Time (After Separation)” to 2 seconds and “Normal Wait Time (After Approach)” to 3 seconds. These setting reduce the size of bubbles found in the printed objects (from 5-25 micron radius to 1-2 micron radius). For 50 micron layers, set exposure time to 1.7 seconds, and for 100 micron layers set exposure time to 2.3 seconds. Shorter times will result in sagging waveguides and waveguides and supports coming apart, while longer times result in hardened plastic that is not part of the model.

In the next screen, set a name for the print and send it to the printer.

## Removing print from printer and cleaning

Always use gloves when removing prints from the printer and cleaning them (The plastic is non-toxic, but is very hard to get off your hands).

Remove the platform from the printer (using the screw at the top) and carefully pry the print off of the platform into a container (there is a metal tool for this that comes with the printer).

Sometimes, there will be some “strings” of slightly hardened plastic hanging off the sides of the model. This is a result of the extended exposure time, and only affects the layers near the beginning of the print (close to the platform, not the ones with the waveguides on them).

Rinse the print thoroughly with Isopropanol making sure to squirt it under all the bridged parts of the waveguide (gently!), rinse the Isopropanol off with water and then dry the print carefully with absorbent paper. Make sure all the bridged parts of the waveguide look white – if they appear clear, they are not bridged (consider rinsing with Iso/water/drying again).

Cure the print in the “Flash” box for 20 minutes.

Limiting the prints exposure to Isopropanol and curing it as soon as possible result in smoother waveguides. However, if the waveguides are connected to the substrate and not bridged, a lot of light will leak from them into the substrate.

## Laser cutting the edges

Light insertion into the waveguides depends largely on smooth, flat ends. The laser cutter below the workshop can do the job, but calibration is tricky.

To get a smooth, flat end, use vector mode, 500 DPI, full speed, 75% power, and cut twice on each end. This means, once the laser is aligned, cut the ends (press “Run”), wait a moment, then cut two more times without moving the model. This is because Cutting at higher power (100% power, slower speed or more DPI) causes damage to the surrounding model (including the waveguides themselves), and cutting at lower power leaves edges that are not cut all the way through. At these settings, the first pass cuts the fiber doing minimal damage to the surrounding area, but leaves a rough edge. The second and third pass straightens the edge to optical smoothness, again without causing significant damage to the surrounding area.

#### Calibration:

So far as I can tell, the laser’s motors are accurate, but they are slightly off from the rulers (0 for the laser is about -0.5 mm on the rulers). Also, the edge of the substrate is not always perfectly straight (see “[Strings](#strings)“). Due to long ends breaking off, only about 300 microns are available for cutting, so calibrating is required for every print.