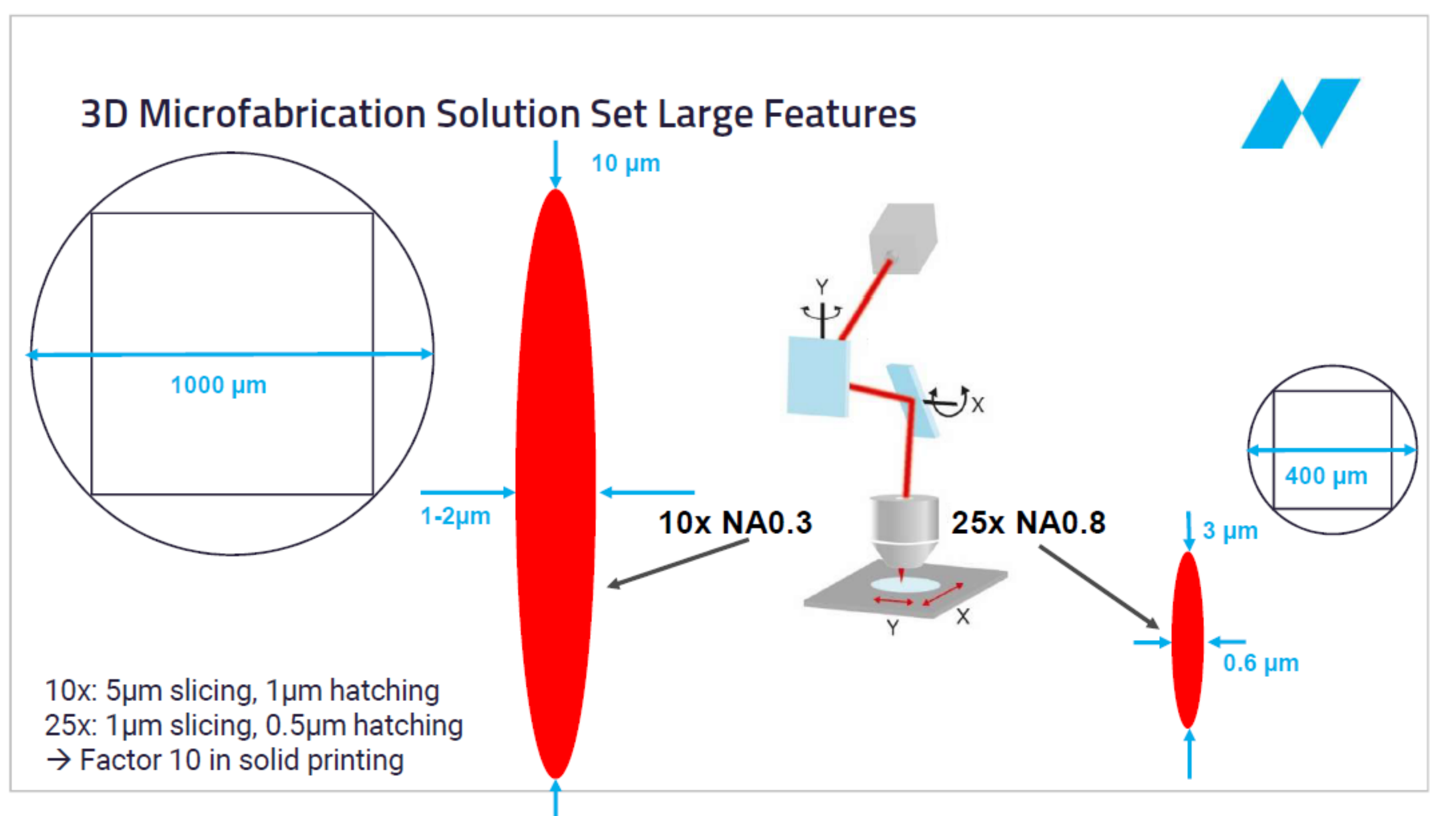
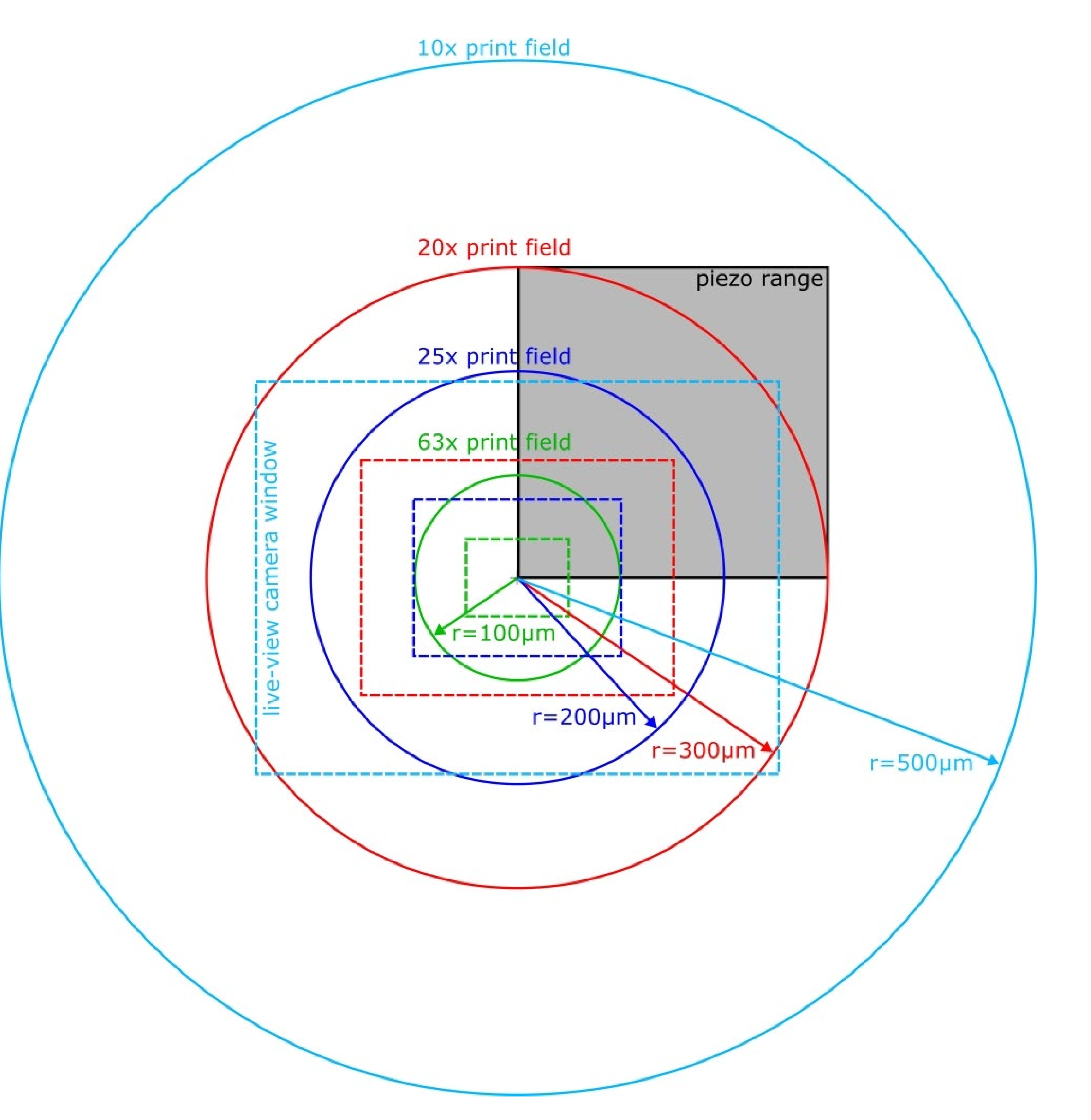
| Objective | | | | | |
|---|---|---|---|---|---|
| Mag, WD | 10x | 20x | 25x, 380um | 63x, 190um | 63x |
| | | | | | |
| Application area | um to mm 3D | 2D-2.5D | um to mm 3D, smooth 3D | 0.2um to 10's of microns 3D | New materials, 0.2um to 10's um |
| NA | 0.3 | 0.5 | 0.8 | 1.4 | 1.4 |
| Micro. Pos. | 4 | 5 | 1 | 3 | 3 |
| Max area sq | 825x825 | 425x425 | 285x285 sq | 140x140 | 140x140 |
| Max diam | 1000 | 600 | 400 | 200 | 200 |
| Min feature size (um) | ~2um x,y ~10um z | ~1um x,y ~6um z | ~0.6um x,y ~3.3um z | ~150nm x,y, ~800nm z | |
| Min spacing between features um | 6um | 1um | 1um | 150nm | |
| Max feature height (um) | 8mm(IPQ) | Thickness of PR | ~3mm (IP-S) | ~3mm (IP DIP) | ~150um (w/170um glass) |
| Typ. Scan Speed mm/s | 100 | 2-8 | 100 | 100 | 20 |
| Max write area (mm) | | | 25mm ITO: 17mm | | |

| Objective | | | | | |
|---|---|---|---|---|---|
| Write speed | 6.8 $mm^3$/hr, 9min/$mm^3$ | | Shell: .77 $mm^3$/hr, 1.3h/$mm^3$<br>Solid: .11 $mm^3$/hr, 9h/$mm^3$ | Solid: .0017 $mm^3$/hr 24days/$mm^3$ | |
| Working Dist (um) | 700 | 2100 | 380 | 360 Dip In<br>170 Oil | 360 Dip In<br>170 Oil |
| Immersion Medium | IP-Q (n=1.487 @ 589nm) | Air | IP-S (n=1.48 @780nm) | IP Dip (n=1.52) | Oil |
| Resist Resins | IP-Q | AZ, SU8, Ormocorp | IP-S | IP-Dip | IP-L, IP-G |
| Substrates | Silicon only, does not work with transparent substrates | Silicon, glass | ITO Glass (n=1.624, 700um thick), Si (n=3.71) | Fused Silica (n=1.45), silicon | Borosilicate glass (n=1.52) 170um thick (coverslip) |
| Slicing (um) | 5 | 3-6 um | 1 (0.2-1.0) | 0.5 (0.1-0.5) | 0.5 |
| Hatch (um) | 1 | 0.7-1.2 um | 0.5 (0.2-0.5) | 0.2 (0.1-0.5) | 0.2 |
| Photoresist Orientation | Z=1 (Dill,PR on bottom) | Z=1 (Air, PR on bottom facing objective) | Z=1 (Dill,PR on bottom facing objective) | Z=1 (Dill,PR on bottom) | Z=0 (Oil, PR on top) |


3D Microfabrication Solution Set Large Features
10 µm
1000 µm
1-2µm
10x NA0.3
25x NA0.8
Y
X
400 µm
3 µm
0.6 µm
10x: 5µm slicing, 1µm hatching
25x: 1µm slicing, 0.5µm hatching
→ Factor 10 in solid printing



10x print field
20x print field
piezo range
25x print field
63x print field
live-view camera window
r=100µm
r=200µm
r=300µm
r=500µm

# Objectives options

| | 63x NA 1.4 | 25x NA 0.8 | 20x NA 0.5 |
|---|---|---|---|
| **Structural Characteristics** | High 3D resolution | High 3D smoothness | High 2D resolution |
| **Immersion Medium** | IP-Dip/Oil | Resin | Air |
| **Working Distance** | 360 – 170 µm† | 380 µm | 2100 µm |
| **Writing Field** | 200 µm | 400 µm | 600 µm |
| **Standard Resin** | IP-Dip/IP-L | IP-S | AZ resists |
| **Refractive Index Contrast** | >0.04 | >0.1 | - |
| ***Typ. Slicing Distance*** | *500 nm* | *1000 nm* | - |
| ***Typ. Hatching Distance*** | *200 nm* | *300 nm* | - |

†Working distance depends on configuration and substrate height.

# Resin and resists options

## Immersion Configurations

| Name | Refractive Index* | Phase | Structure Characteristics | Printing Mode | Configuration |
|---|---|---|---|---|---|
| IP-L 780 | 1.48 | Liquid | High resolution | Oil | 63x/Cover slip |
| IP-G 780 | 1.49 | Gel | Flying features | Oil | 63x/Cover slip |
| IP-Dip | 1.51 | Liquid | High resolution | DiLL | 63x/Fused silica |
| IP-S | 1.48 | Liquid | High smoothness | DiLL | 25x/ITO glass |

## Air Configurations

| Name | Refractive Index | Phase | Resist Tone |
|---|---|---|---|
| AZ resists | 1.6173 – 1.6953† | Solid | Positive |
| SU-8 | 1.58 | Solid | Negative |
| Ormocomp | 1.52 | Liquid | Negative |

* Measured at 20°C at 780 nm.
† Refractive index depends on the specific resist and wavelength. Unbleached values at 405 nm are shown here.

| 2PP resin | Refractive index | Phase | Characteristics | Print Set | Objective | Substrate |
|---|---|---|---|---|---|---|
| IP-Dip | 1.521 | liquid | high resolution | 3D SF | 63x | fused silica (3D SF DiLL), silicon (3D LF DiLL) |
| IP-L 780 | 1.485 | liquid | high resolution | 3D SF Oil | 63x | borosilicate (3D SF Oil) |
| IP-G 780 | 1.495 before bake | gel | high resolution, flying features | 3D SF Oil | 63x | borosilicate (3D SF Oil) |
| IP-S | 1.486 | liquid | high smoothness, mesoscale | 3D MF | 25x | ITO-coated (3D MF DiLL), silicon (3D LF DiLL) |
| IP-Q | 1.487 | liquid | mesoscale | 3D LF | 10x | silicon (3D LF DiLL) |
| IP-Visio | 1.486 | liquid | low fluorescence, non-cytotoxic | 3D MF | 25x | ITO-coated (3D MF DiLL) |
| AZ 5214E | 1.6990 | solid | 2D lithography | 2D ML | 20x | silicon (3D LF DiLL) |
| AZ 9260 | 1.6963 | solid | 2D lithography | 2D ML | 20x | ITO-coated (3D MF DiLL) |
| AZ MIR 701 | 1.7039 | solid | 2D lithography | 2D ML | 20x | fused silica (3D SF DiLL) |
| AZ 40XT | 1.5851 | solid | 2D lithography | 2D ML | 20x | silicon (3D LF DiLL) |
| SU-8 | 1.58 | solid | 2D lithography | 2D ML, 3D SF Oil | 20x, 63x | fused silica (3D SF DiLL), silicon (3D LF DiLL), borosilicate (3D SF Oil) |
| Ormocomp | 1.520 | liquid | transparent | 2D ML, 3D SF Oil | 20x, 63x | fused silica (3D SF DiLL), silicon (3D LF DiLL), borosilicate (3D SF Oil) |

Other 2PP resins used with the Nanoscribe 3D printer.

| 2PP resin | Refractive index | Phase | Characteristics | Print Set | Objective | Substrate |
|---|---|---|---|---|---|---|
| AZ 1500 | 1.7123 | solid | 2D lithography | 2D ML | 20x | fused silica (3D SF DiLL), silicon (3D LF DiLL) |
| AZ 6600 | 1.7112 | solid | 2D lithography | 2D ML | 20x | fused silica (3D SF DiLL), silicon (3D LF DiLL) |
| AZ ECI 3027 | 1.7014 | solid | 2D lithography | 2D ML | 20x | fused silica (3D SF DiLL), silicon (3D LF DiLL) |
| AZ nLOF | 1.6389 | solid | 2D lithography | 2D ML | 20x | fused silica (3D SF DiLL), silicon (3D LF DiLL) |

## 10x Objective

Use the 10x immersion objective for printing large features in conjunction with the IP-Q resin.

A resin stop is required (supplied with the 3D LF). This prevents 2PP resin from creeping into the objective nosepiece.

| Property | Value | Comments |
|---|---|---|
| Objective | 10x NA 0.3 | see also objective overview |
| Immersion (DiLL) mode | yes | |
| Immersion media | 2PP resin | IP resins from Nanoscribe are safe to use with the objective |
| Working distance *WD* | 700 µm | |
| Objective opening angle *α* | 35° | |
| Objective lens diameter *D* | 2.5 mm | |
| Felt ring | not available | use the dedicated resin stop to prevent damage to the printer |
| Printing field (Galvo Ø) | 1000 µm | stage movement allows for a larger effective printing field |
| Theoretical lateral ($a_{xy}$) and axial resolution ($a_z$);[ref] [aspect ratio] | $a_{xy} = 1.6$ µm; $a_z = 25.4$ µm; 16.0 | for 780 nm laser wavelength, IP-Q and 20°C; voxel size and line width depend on solution set and print parameters; single lines are very unstable (high aspect ratio; see article for more information) |
| Standard 2PP resin | IP-Q | |
| Solution set | 3D LF | |
| Δn required @ 830nm | >0.5 | required substrate thickness to distinguish between two interface signals: >700 um (because of the large depth of focus) |
| Typical slicing distance | 5 µm | standard recipe for IP-Q |
| Typical hatching distance | 1 µm | |

## 25x Objective

The 25x immersion objective is used for printing medium-sized features. The best surface smoothness is achieved in conjunction with IP-S, hence this objective is recommended for printing micro-optics.

A felt ring is available that prevents 2PP resin from creeping into the objective nosepiece.

Two versions of this objective are in use. Each has equivalent optical performance, but differs in shape and felt ring size as well as an additional "SIL" (silicone oil) marking on the adjustment ring for the latest version. The position of the adjustment ring markers are also mirrored compared to the previous objective revision.

*Table 1: Objective properties*

| Property | Value | Comments |
|---|---|---|
| Objective | 25x NA0.8 | see also objective overview |
| Immersion (DiLL) mode | yes | |
| Immersion media | oil/glycol/water/2PP resin | Most IP resins from Nanoscribe are safe to use with this objective |
| Working distance *WD* | 380 µm | |
| Objective opening angle *a* | 31° | |
| Objective lens diameter *D* | 5.2 mm | |
| Felt ring size | 30 mm / 32 mm | depending on objective version |
| Printing field (Galvo Ø) | 400 µm | stage movement allows for a larger printing field |
| Theoretical lateral ($a_{xy}$) and axial resolution ($a_z$);[ref] [aspect ratio] | $a_{xy} = 595$ nm, $a_z = 3313$ nm; 5.6 | for 780 nm laser wavelength, IP-S and 25°C; voxel size and line width depend on solution set and print parameters |
| Standard 2PP resin | IP-S | |
| Solution set | 3D MF | |
| Δn required @ 830nm | >0.1 | |
| Typical slicing distance | 1 µm | standard recipe for IP-S |
| Typical hatching distance | 0.5 µm | |

## 63x Objective

The 63x immersion objective is the objective for printing small features. For printing the finest features possible, IP-Dip and IP-L 780 are recommended.

A felt ring prevents 2PP resin or oil creeping into the objective nosepiece.

| Property | Value | Comments |
| --- | --- | --- |
| Objective | 63x NA1.4 | see also objective overview |
| Immersion (DiLL) mode | yes | |
| Immersion medium | oil/2PP resin | with the exception of IP-G (780), IP resins from Nanoscribe are safe to use as immersion medium |
| Working distance *WD* | 360 µm (-170 µm) | when working in oil immersion configuration, the range is reduced by 170 µm owing to the substrate thickness |
| Objective opening angle *α* | 12° | |
| Objective lens diameter *D* | 5.5 mm | |
| Felt ring size | 22.5 mm | |
| Printing field (galvo Ø) | 200 µm | stage movement allows for a larger printing area |
| Theoretical lateral ($a_{xy}$) and axial resolution ($a_z$);[ref] [aspect ratio] | $a_{xy} = 340$ nm, $a_z = 826$ nm; 2.4 | for 780 nm laser wavelength, IP-Dip and 25°C; voxel size and line width depend on solution set and print parameters |
| Standard 2PP resin | IP-Dip | IP-L 780 or IP-G 780 are also suitable |
| Solution set | 3D SF | or 3D SF Oil |
| Δn required @ 830nm | >0.04 | |
| Typical slicing distance | 0.3 µm | standard recipe for IP-Dip |
| Typical hatching distance | 0.2 µm | |

20x Objective

The 20x objective is the air objective for 2D and 2.5D lithography. AZ resins give good results in structuring thin- and thick-film resists.

*Table 1: Objective properties*

| Property | Value | Comments |
|---|---|---|
| Objective | 20x NA0.5 | see also objective overview |
| Immersion (DiLL) mode | no | therefore no felt ring required |
| Working distance | 2100 µm | |
| Printing field (galvo Ø) | 600 µm | stage movement allows for a larger printing field |
| Theoretical lateral ($a_{xy}$) and axial resolution ($a_z$);[ref] [aspect ratio] | $a_{xy}$ = 951 nm, $a_z$ = 5824 nm; 6.1 | for 780 nm laser wavelength and air; voxel size and line width depend on print set and print parameters |
| Standard resin | AZ | |
| Print set | 2D ML | |
| Δn required | no limitation | typically the interface between substrate and air is found |
| Typical slicing distance | 3-6 µm | standard recipe for AZ resins |
| Typical hatching distance | 0.7-1.2 µm | |