Lesson 48. A Microlithography Lens from Scratch

The computer you are using just now has a CPU with a wafer that was exposed with a very complicated lens. Such lenses, which may contain from 20 to 30 elements or more, are the most highly corrected and precise lenses the world has ever seen. The sales price runs to seven figures. You may never be called upon to design one, but if you are, or if you are serious about learning the art of lens design, it would be a good idea to learn how. This lesson will give an example.

Here are the specs:

Number of elements: 22

Object height: 31 mm; this is a mask of the pattern to be created on the wafer

Object-space NA: 0.2

Wavelengths: UV

Image size at wafer: 12.66 mm

Total length not more than 1200 mm

This kind of lens, which works at finite conjugates at both object and image, can best be designed in two steps. First, we will find a configuration for the left half, from the mask to a central point where the light is collimated. Then we will design a second lens, for the right half, to take the collimated beam and image it onto the wafer. We will ask DSEARCH for an 11-element lens for the left half.

Here is the input for DSEARCH:

```
CORE 14
TIME
DSEARCH 2 QUIET

SYSTEM
ID DSEARCH LEFT
UNI MM
OBA 15 31 3 31
OSNA .2
TCO
WAVL .354732 .354712 .354692
AFOC
END

GOALS
ELEM 11
TOTL 600 .1
TOPD .01
NPASS 50
QUICK 20 50
ANNEAL 50 10 Q
SNAP 10
RSTART 1000
ASTART 25
THSTART 12
FOV 0 .5 .707 1
```
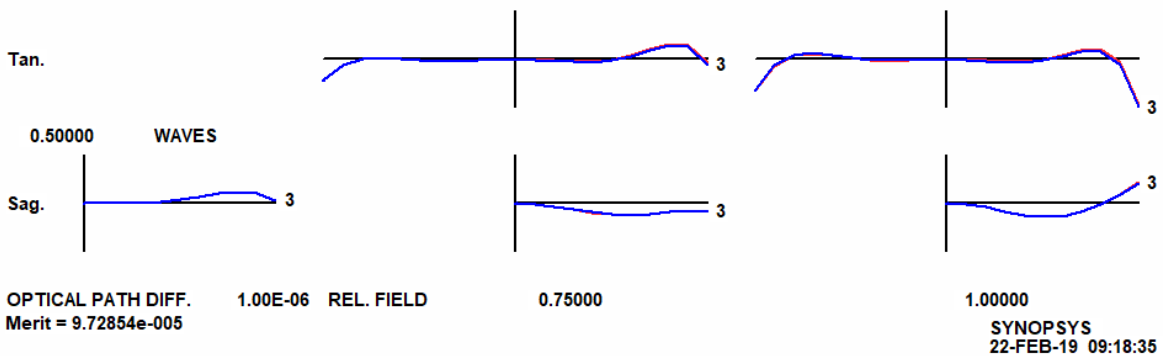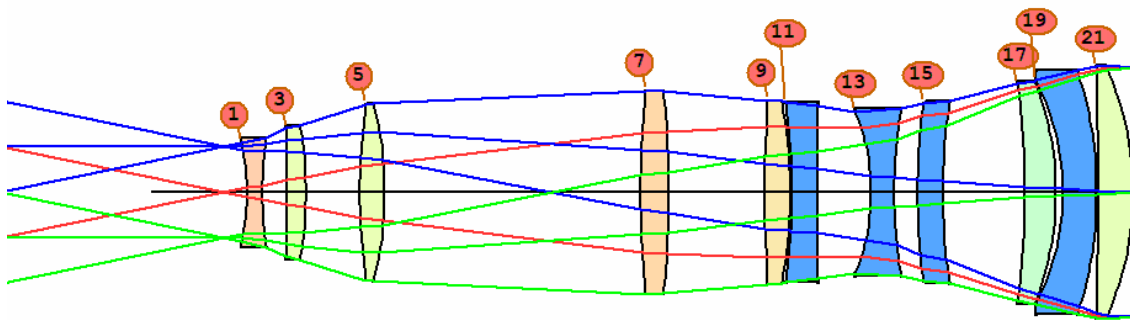
```
FWT 1 1 1 1

END

SPECIAL PANT
CBOUNDS 1.88 -6.57 1.49 78.55
FBOUNDS 1.92 22.16 1.50 62.67
CUL 1.6
FUL 1.6
END

SPECIAL AANT
ADT 7 .01 1
M 0 .1 A SAP
M 0 .1 A P YA 1 0 0 0 LB1
END
GO
TIME
```

This input runs for 11 minutes and returns a very good starting lens, which we save.

SAVE LEFT11.

Now activate ACON 2 and enter the data for DSEARCH for designing the right half.

```
CORE 14
TIME
DSEARCH 3 QUIET
SYSTEM
ID DSEARCH RIGHT
```

```
UNI MM
OBB 0 4 83.36
WAVL .354732 .354712 .354692
END

GOALS
ELEM 11
TOTL 600 .01
FNUM 1
BACK 11 SET
TOPD .01
STOP FIRST
STOP FIXED
NPASS 50
QUICK 20 50
ANNEAL 50 10 Q
SNAP 10
RSTART 1000
ASTART 25
THSTART 12

FOV 0 .5 .707 1
FWT 1 1 1 1

END

SPECIAL PANT
CBOUNDS 1.88 −6.57 1.49 78.55
FBOUNDS 1.92 22.16 1.50 62.67
CUL 1.6
FUL 1.6
END

SPECIAL AANT
ADT 7 .01 1
M 0 1 A P HH 1
M 0 10 A P YA 1
S GIHT
M 0 10 A DI3
END
GO
TIME
```
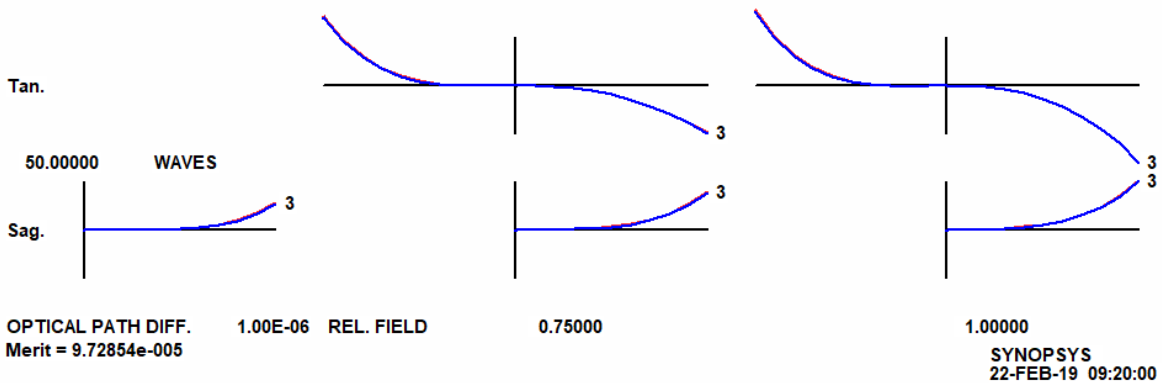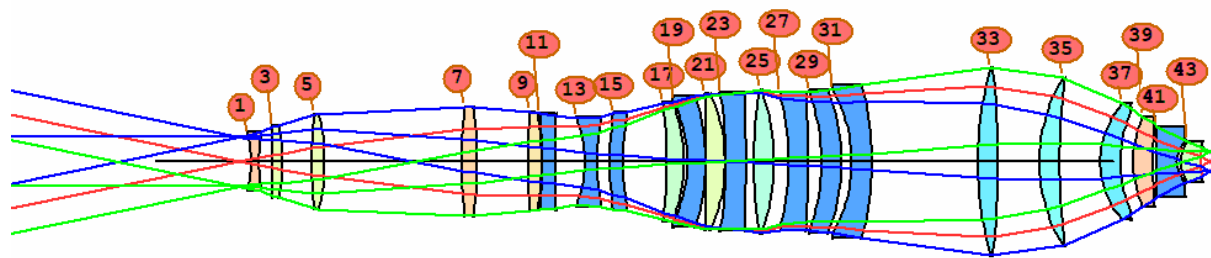
This runs for 12 minutes, again with excellent results, and we save this version.

SAVE RIGHT11.

Tan.

2.00000   WAVES

Sag.

OPTICAL PATH DIFF.   1.00E-06   REL. FIELD   0.75000   1.00000
Merit = 0.00512082   SYNOPSYS
                                                                                        22-FEB-19 09:18:52

Now combine the two halves. Activate ACON 1 again, and type

COMBINE 23

RIGHT11

They are now combined into one lens.

Open the WorkSheet and add a YMT solve to surface 44. The system now looks like this:

Tan.

50.00000   WAVES

Sag.

OPTICAL PATH DIFF.   1.00E-06   REL. FIELD   0.75000   1.00000
Merit = 9.72854e-005   SYNOPSYS
                                                                    22-FEB-19 09:20:00

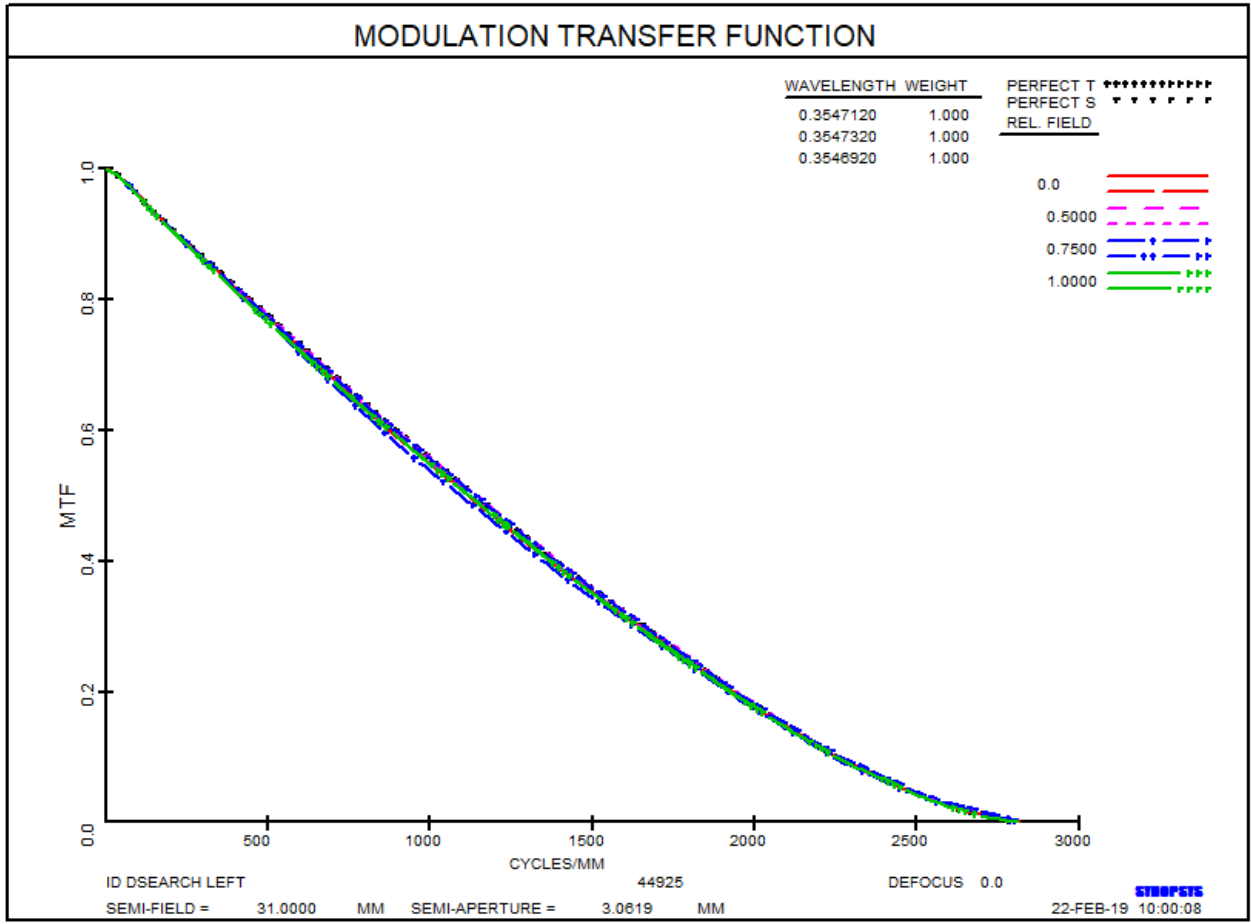Now open the optimization MACro prepared by DSEARCH for the right section, and change the TOTL requirement, specifying an upper limit of 1200 (LUL 1200 .01 1 A TOTL). Also add a target for the back focus, which is now controlled by the solve. (M 11 .1 A BACK). Then run the MACro and anneal (33,2,50). The lens is improved.

Open the MRG dialog, select the Ohara catalog, click the iLine box, and then OK. In about 14 minutes, all model glasses have been replaced with preferred iLine glasses, and the image is superb. After more optimization and annealing, it is even better. Distortion is less than 0.1 micrometer. Success!

Tan.

0.10000 WAVES

Sag.
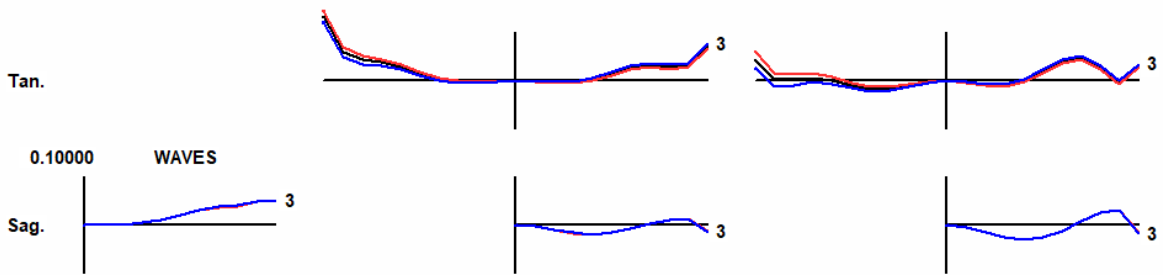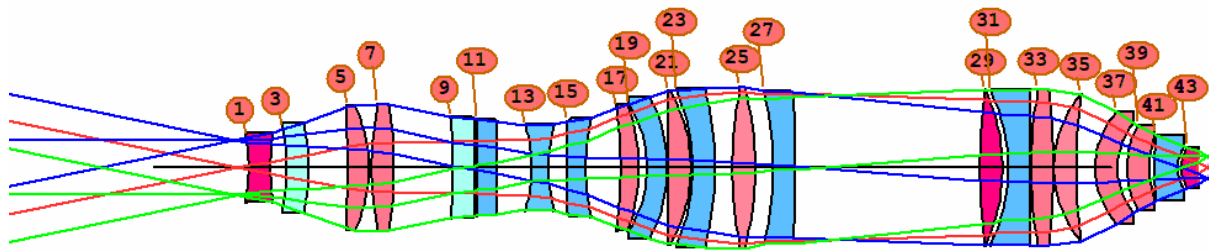
OPTICAL PATH DIFF.   1.00E-06 REL. FIELD   0.75000   1.00000
Merit = 1.13854e-005   SYNOPSYS
                                                                      22-FEB-19 10:00:42

MODULATION TRANSFER FUNCTION

WAVELENGTH	WEIGHT
0.3547120	1.000
0.3547320	1.000
0.3546920	1.000

PERFECT T
PERFECT S
REL. FIELD

0.0
0.5000
0.7500
1.0000

ID DSEARCH LEFT   44925   DEFOCUS 0.0
                                                                             SYNOPSYS
SEMI-FIELD =   31.0000   MM   SEMI-APERTURE =   3.0619   MM   22-FEB-19 10:00:08

LINEAR DISTORTION

FRACTIONAL FIELD


```
        S        1.0

                 0.8

                 0.6

                 0.4

                 0.2


-1.0000E-04   -5.0000E-05    0.0      5.0000E-05   1.0000E-04 MM

    LINEAR DISTORTION
    COLOR  2 WAVELENGTH    0.354712 uM
    ID DSEARCH LEFT                              44925

    REFERENCE FIELD POINT IS AT  1.00E-03
```

SYNOPSYS
22-FEB-19 10:01:53

So there you have it. In less than 45 minutes, we have an excellent microlithography lens. With no starting design. Matched to real glasses.

No other lens design program in the world can come up with designs this good so quickly. Be glad you chose SYNOPSYS for your lens design needs.