PROYECTO FIN DE CARRERA

DISEÑO, CONSTRUCCIÓN Y EVALUACIÓN DE UN LÁSER DE CAVIDAD EXTERNA CON LONGITUD DE ONDA DE EMISIÓN SINTONIZABLE

ANEXOS 2/2

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Anexo I
Hojas características

I.1. Chip de ganancia

COVEGA

COVEGA Corporation
Single Angled Facet Module (SAF)
Part Description: 14 Pin Butterfly Packaged SAF
Package Description:1176-2-0-T-S-A

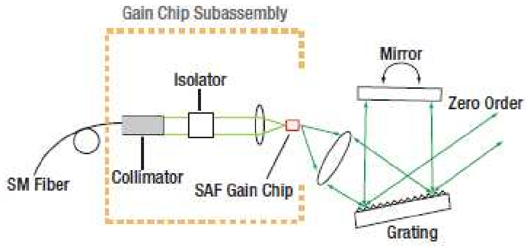
Serial Number: SAF-6662-11736.58.B01
Test Date: 15-Dec-09

Summary of Test Data			
CW; T (Chip) =28.0 °C, T (Case) =30.0 °C			
Parameter			
Operating Current	I_{OP}	300	mA
Center Wavelength	λ_C	1520.1	nm
ASE Power @ I_{OP}	P_{ASE}	0.5	mW
Optical Bandwidth @ I_{OP}	BW	133.8	nm
Max Gain Ripple (rms) @ I_{OP}, Res. BW = 0.01 nm	δG	0.12	dB
Forward Voltage @ I_{OP}	V_F	1.31	V
TEC Operation			
- TEC Current	I_{TEC}	0.20	A
- TEC Voltage	V_{TEC}	0.35	V
- Thermistor Resistance	R_{TH}	10K	Ω
Steinhart Constants : a=1.129241E-3; b=2.341077E-4; c=8.775468E-8			

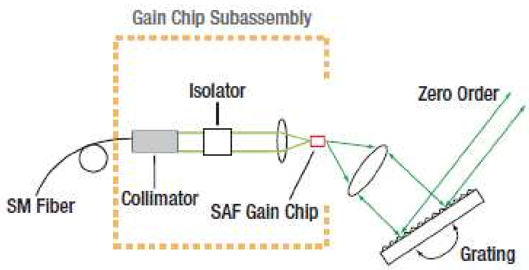
SAF Gain Chip Assemblies, λ_C = 1320 and 1550 nm (Page 1 of 2)

Thorlabs offers two varieties of single-angled-facet gain chips mounted in a fiber-coupled subassemblies for easy integration into ECL cavities. The SAF1174S is offered for the 1300 to 1400 nm range, whereas the SAF1176S is fabricated for the 1500 to 1600 nm range. These devices are optimized for high gain, high power, broad tunability, and minimal mode hopping.

Both devices are superior gain elements for tunable Extended Cavity Lasers (ECLs) in term of laser stability, output power, and spectral quality. To achieve these qualities, the SAF gain chips have an angled waveguide and AR coatings on both ends to virtually eliminate unwanted reflective feedback from the intra-cavity facet of the gain chip. In addition, the devices use a proven SOA structure to give designers of tunable ECLs the highest power and widest tuning range available in the market.



Basic Littman-Metcalf Configuration



Basic Littrow Configuration

To simplify integration of the gain chip into an extended cavity design, Thorlabs offers an open butterfly package assembly, which couples the output of the normal facet to a fiber pigtail. By using the assembly, the designer gains the advantage of a fiber-coupled ECL cavity.

The butterfly assembly includes the gain chip mounted on a thermoelectric cooler such that the gain chip's normal facet is pre-aligned with a collimating lens, optical isolator, and a single mode fiber pigtail. The optical isolator prevents any unwanted reflections from an external system from disrupting the ECL in operation. All devices undergo a monitored burn-in procedure to assure long-term stability and device quality.

Optical-Electrical Characteristics*

ITEM#		SAF1174S			SAF1176S		
Parameter	Symbol	Min	Typical	Max	Min	Typical	Max
Center Wavelength	λ	1290 nm	1320 nm	1340 nm	1500 nm	1550 nm	1600 nm
ASE 3 dB Bandwidth	BW	60 nm	80 nm	–	60 nm	80 nm	–
ASE Power @ I_{OP}	P_{OUT}	0.4 mW	0.5 mW	–	0.4 mW	0.5 mW	–
Peak Gain @ I_{OP}	G	–	39 dB	–	–	17 dB	–
Gain Ripple, rms**		–	0.35 dB	1 dB	–	0.1 dB	0.4 dB
Angled Facet Reflectivity	R_1	–	0.005%	0.01%	–	0.005%	0.01%
Normal Facet Reflectivity	R_2	–	10%	–	–	10%	–
Lateral Beam Exit Angle	θ_{EXT}	–	26.5°	–	–	19.5°	–
Beam Divergence	θ_T	20°	30°	40°	27°	31°	35°
(FWHM)	θ_L	10°	20°	30°	14°	17°	21°
Operating Current	I_{OP}	–	600 mA	800 mA	–	300 mA	500 mA
Forward Voltage	V_F	–	1.3 V	1.8 V	–	1.1 V	1.4 V
Chip Length	L	–	2.0 mm	–	–	1.0 mm	–

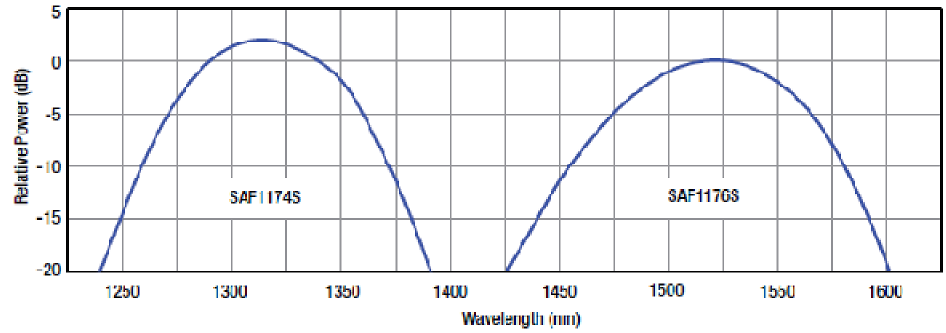
* Specifications based on Littrow external cavity configuration, R_2 = 10%, external cavity losses <5 dB, CWT (Chip) = 25%

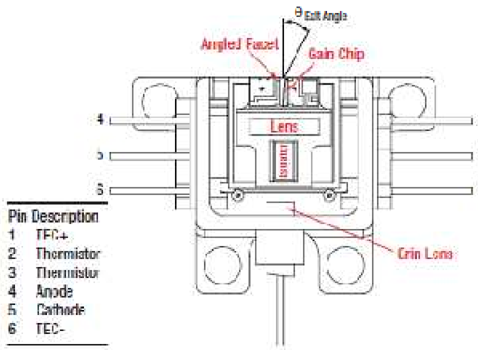
** @ I_{OP} (Res. BW = 0.1 nm)

SAF Gain Chip Assemblies, λ_C = 1320 and 1550 nm (Page 2 of 2)

The innovative design of an SAF gain chip is ideal for use in external cavity lasers because it virtually eliminates the unwanted feedback from the intracavity facet of the gain chip. These devices offer superior performance in a wide variety of external cavity configurations. Shown below are typical SAF1174S and SAF1176S ASE spectras, details on the packaged devices, and the resultanting tuning curves.

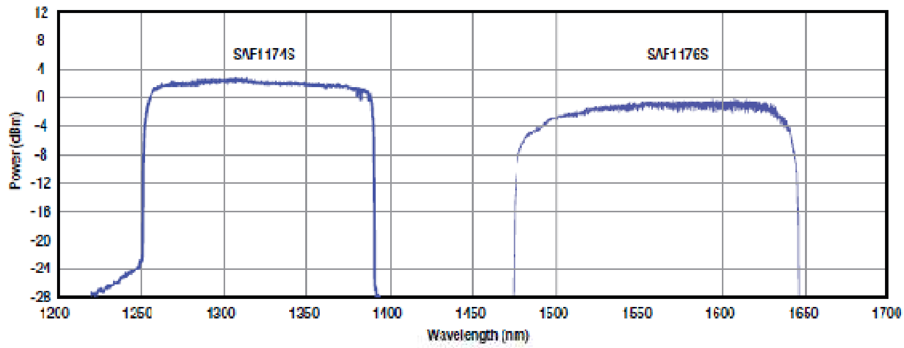
SAF Gain Chip ASE Spectra





Schematic of Gain Chip in Subassembly

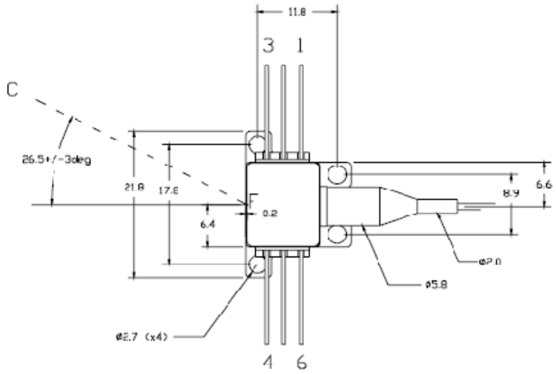
Sample Results Using a Basic Littrow Configuration



ITEM#	$	£	€	RMB	DESCRIPTION
SAF1174S	$ 2,500.00	£ 1,733.00	€ 2,219.50	¥ 21,111.00	1320 nm Single-Angled-Facet Gain Chip in Subassembly, R_2 = 10%
SAF1176S	$ 2,500.00	£ 1,733.00	€ 2,219.50	¥ 21,111.00	1550 nm Single-Angled-Facet Gain Chip Subassembly, R_2 = 10%

SAF1175: Custom Thorlabs Single Angled Facet Gain Chip in Custom Butterfly Housing
Housing and Fiber Details

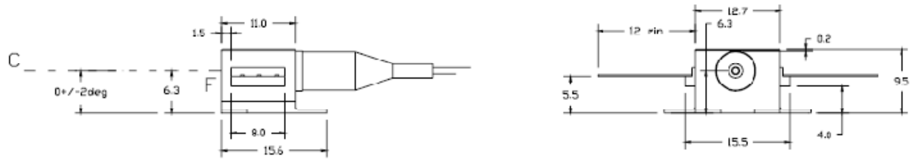
Package Outline and pin-out :



PIN IDENTIFICATION

1. TEC +
2. Thermistor
3. Thermistor
4. Dev Anode
5. Dev Cathode
6. TEC -

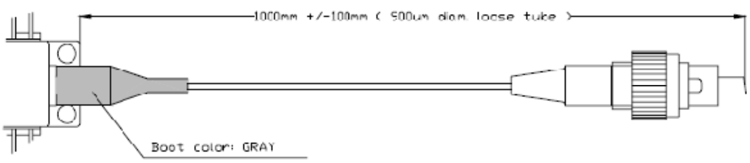
Recommended mounting torque is 10-20oz.in (0.07-0.14N.m).



dimensions in mm

Note : F denotes emission point from chip facet.
FC denotes central axis for emergent beam

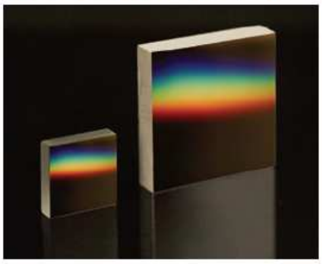
Fiber Tail Detail (1220nm wavelength device) :



OPTION K : Corning HI 1060 (or Nufern 1060-XP): Loose Tube / FC/APC

I.2. Rejillas de difracción

Ruled Diffraction Gratings



Highlights

- Higher Efficiencies than Holographic Gratings
- Offered in 3 Sizes:
  - 12.7 x 12.7 x 6 mm
  - 25 x 25 x 6 mm
  - 50 x 50 x 9.5 mm

Specifications

- **Efficiencies:** 60-80% at Blaze λ (in Littrow)
- **Dimensional Tolerances:** ±0.5 mm
- **Ghost Intensities:** <0.5% of Parent Line
- **Damage Threshold:** 350 mJ/cm² at 200 ns (Pulsed); 40 W/cm² (CW)
- **Surface Quality:** 60-40 Scratch-Dig

These replicated, ruled diffraction gratings are offered in a variety of sizes and blaze angles. Ruled gratings typically can achieve higher efficiencies than holographic gratings due to their blaze angles. Efficiency curves for all of these gratings are shown on the following pages to aid in selection of the appropriate grating.

ITEM#	GROOVES (lines/mm)	BLAZE λ (nm)	BLAZE ANGLE	DISPERSION (nm/mrad)	SIZE	$	£	€	RMB
GR13-0303	300	300	2° 34'	3.33	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80
GR13-0305	300	500	4° 18'	3.32	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80
GR13-0310	300	1000	8° 36'	3.30	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80
GR13-0605	600	500	8° 37'	1.65	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80
GR13-0608	600	750	13° 0'	1.62	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80
GR13-0610	600	1000	17° 27'	1.59	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80
GR13-0616	600	1600	28° 41'	1.46	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80
GR13-1203	1200	300	10° 22'	0.82	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80
GR13-1205	1200	500	17° 27'	0.80	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80
GR13-1208	1200	750	26° 44'	0.74	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80
GR13-1210	1200	1000	36° 52'	0.67	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80
GR13-1850	1800	500	26° 44'	0.50	12.7 x 12.7 x 6 mm	$ 61.20	£ 42.50	€ 54,40	¥ 516.80

ITEM#	GROOVES (lines/mm)	BLAZE λ (nm)	BLAZE ANGLE	DISPERSION (nm/mrad)	SIZE	$	£	€	RMB
GR25-0303	300	300	2° 34'	3.33	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-0305	300	500	4° 18'	3.32	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-0310	300	1000	8° 36'	3.30	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-0605	600	500	8° 37'	1.65	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-0608	600	750	13° 0'	1.62	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-0610	600	1000	17° 27'	1.59	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-0613	600	1250	22° 1'	1.55	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-0616	600	1600	28° 41'	1.46	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-1204	1200	400	13° 53'	0.81	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-1205	1200	500	17° 27'	0.80	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-1208	1200	750	26° 44'	0.74	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-1210	1200	1000	36° 52'	0.67	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30
GR25-1850	1800	500	26° 44'	0.50	25 x 25 x 6 mm	$ 102.00	£ 70.80	€ 90,60	¥ 861.30

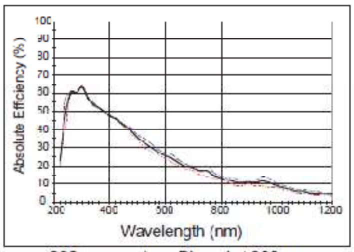
ITEM#	GROOVES (lines/mm)	BLAZE λ (nm)	BLAZE ANGLE	DISPERSION (nm/mrad)	SIZE	$	£	€	RMB
GR50-0305	300	500	4° 18'	3.32	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-0310	300	1000	8° 36'	3.30	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-0603	600	300	5° 9'	1.66	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-0605	600	500	8° 37'	1.65	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-0608	600	750	13° 0'	1.62	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-0610	600	1000	17° 27'	1.59	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-0613	600	1250	22° 1'	1.55	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-0616	600	1600	28° 41'	1.46	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-1204	1200	400	13° 53'	0.81	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-1205	1200	500	17° 27'	0.80	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-1208	1200	750	26° 44'	0.74	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-1210	1200	1000	36° 52'	0.67	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60
GR50-1850	1800	500	26° 44'	0.50	50 x 50 x 9.5 mm	$ 179.60	£ 124.60	€ 159,50	¥ 1,516.60

Handling of Gratings

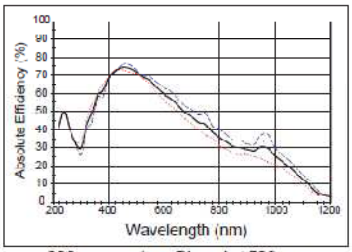
The surface of a diffraction grating can be easily damaged by fingerprints, aerosols, moisture, or the slightest contact with any abrasive material. Gratings should only be handled when necessary and always held by the sides. Latex gloves or a similar protective covering should be worn to prevent transfer of oil from fingers to the grating surface.

Any attempt to clean a grating with a solvent voids the warranty. No attempt should be made to clean a grating other than blowing off dust with clean, dry air or nitrogen.

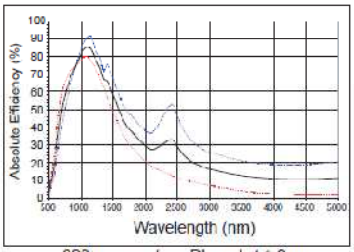
Ruled Diffraction Gratings (See Our Website for Enlarged Plots)



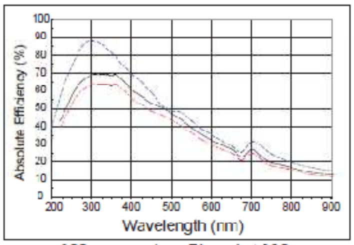
300 grooves/mm Blazed at 300 nm



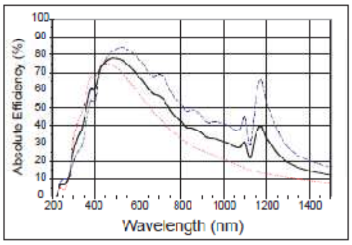
300 grooves/mm Blazed at 500 nm



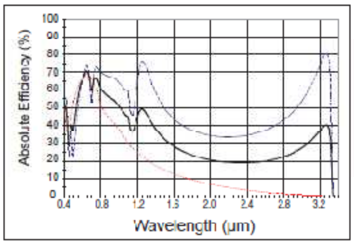
300 grooves/mm Blazed at 1.0 µm



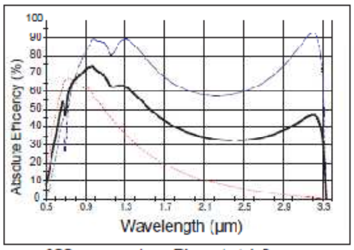
600 grooves/mm Blazed at 300 nm



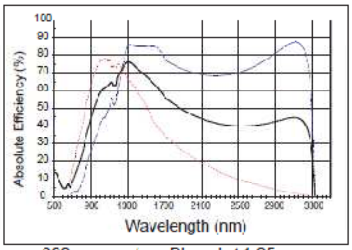
600 grooves/mm Blazed at 500 nm



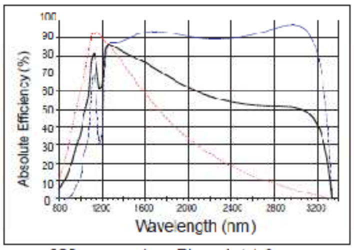
600 grooves/mm Blazed at 750 nm



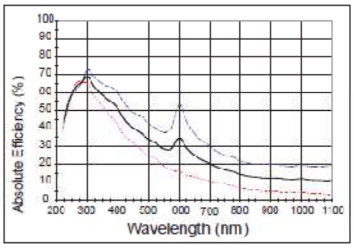
600 grooves/mm Blazed at 1.0 µm



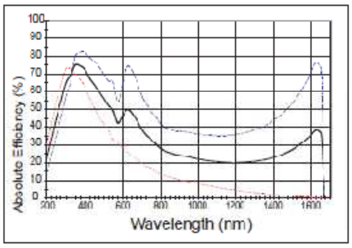
600 grooves/mm Blazed at 1.25 µm



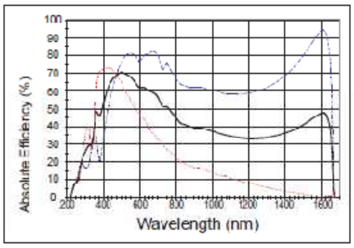
600 grooves/mm Blazed at 1.6 µm



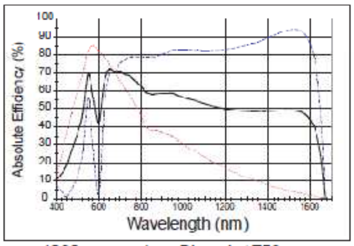
1200 grooves/mm Blazed at 300 nm



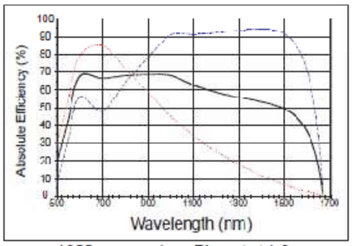
1200 grooves/mm Blazed at 400 nm



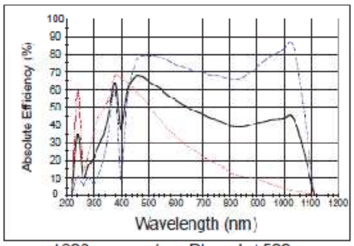
1200 grooves/mm Blazed at 500 nm



1200 grooves/mm Blazed at 750 nm



1200 grooves/mm Blazed at 1.0 µm



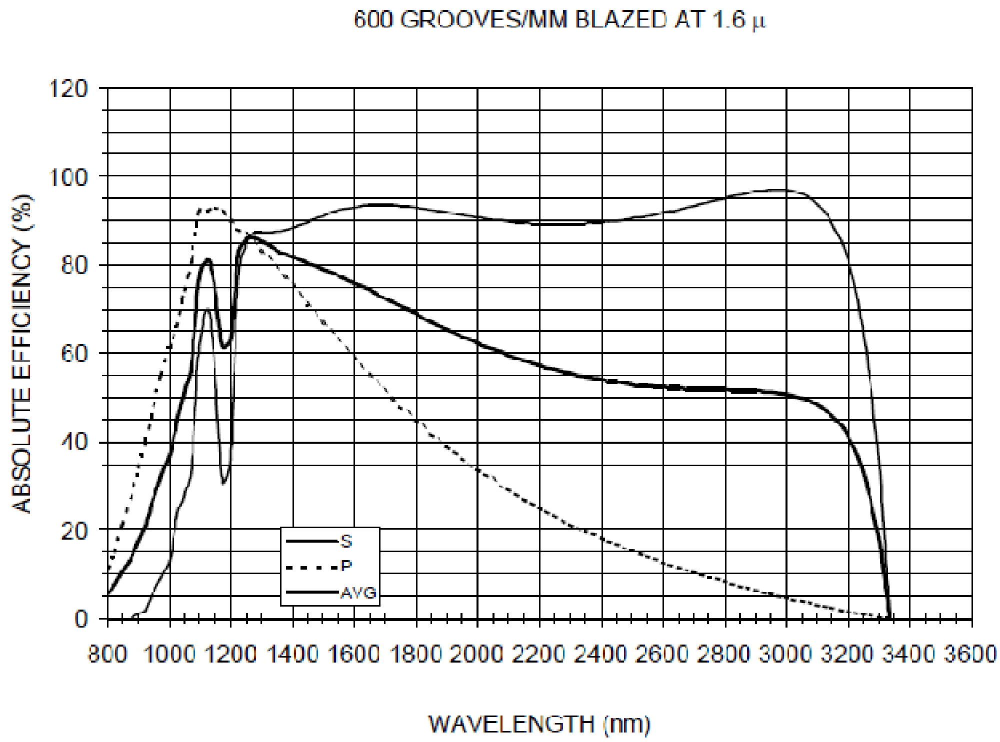
1800 grooves/mm Blazed at 500 nm

Efficiency Curve Key

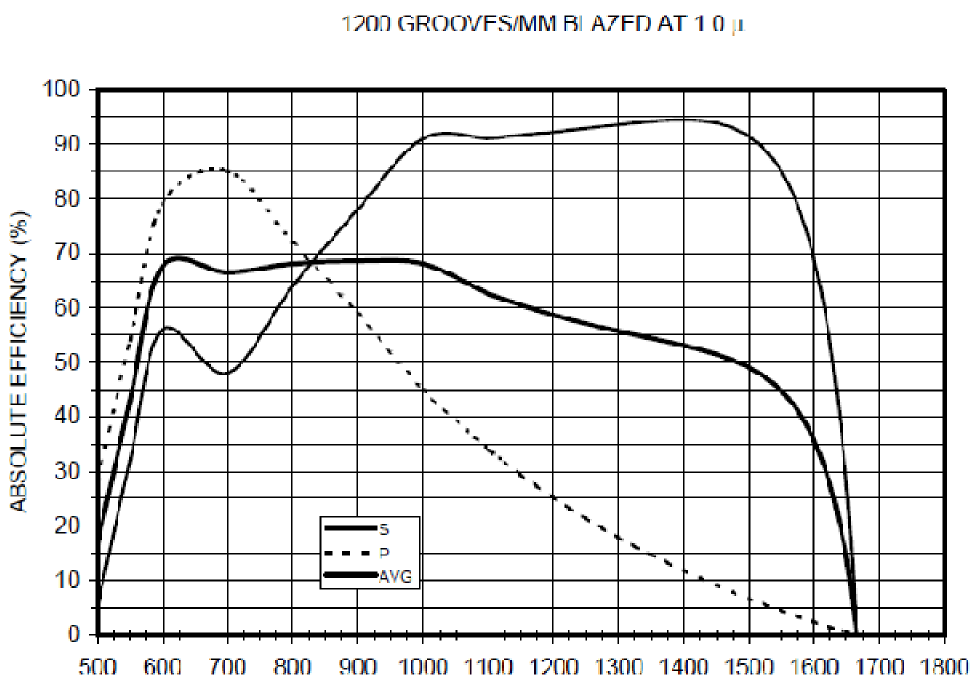
S-Polarized Polarization
P-Polarized Polarization
Average

*All gratings are measured in the Littrow mounting configuration
*All gratings utilize an aluminum (Al) reflective coat

I.2.1 Rejilla de difracción de 600 líneas/mm



I.2.2 Rejilla de difracción de 1200 líneas/mm



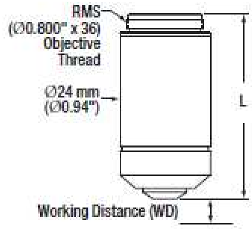
I.3. Objetivo microscópico (10X)

Visible Imaging Objectives

RMS4X RMS10X

Features

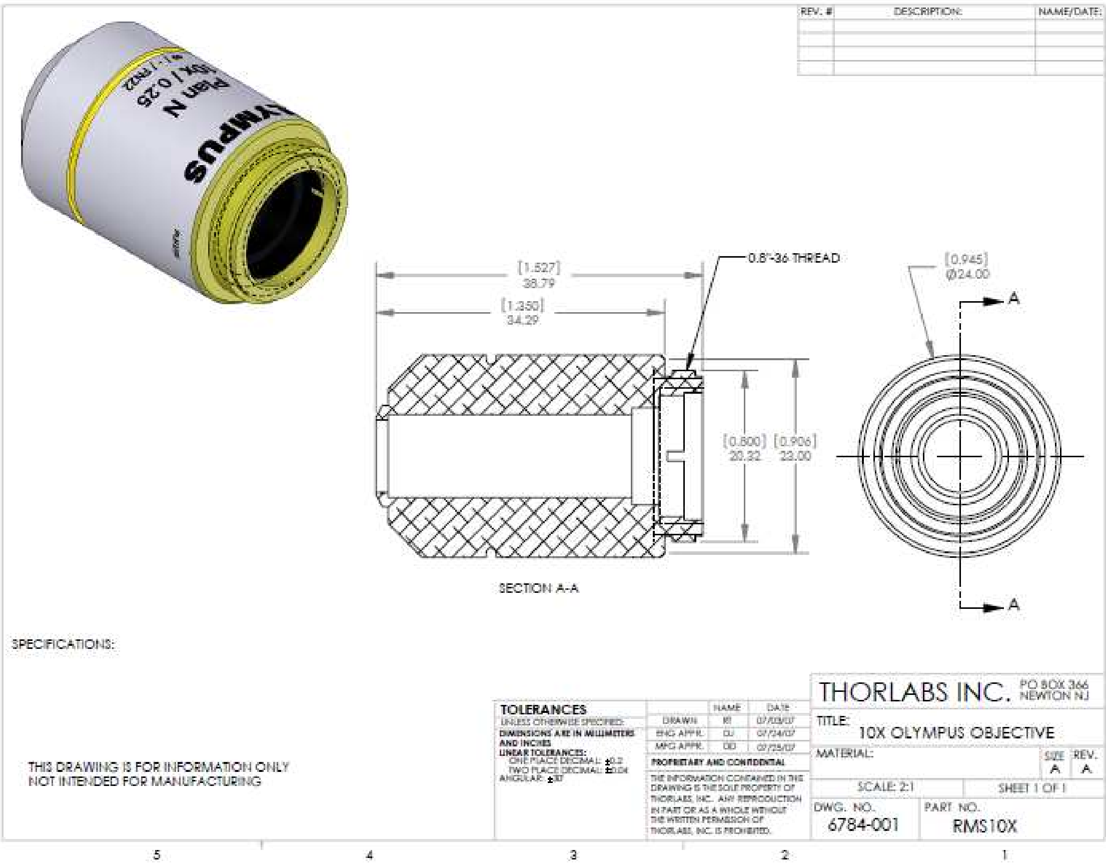
- Infinity Corrected
- 4X, 10X, 20X, or 40X Magnification
- Achromatic Objective



Thorlabs offers a line of RMS-threaded, infinity-corrected, imaging objectives. Optimized for brightfield imaging, these objectives provide superb field flatness. They are achromatically designed and have an ultra wide antireflection coating. Our imaging objectives, unlike our focusing objectives, typically feature shorter working distances and an AR coating for the visible spectrum.

Please refer to our website for complete models and drawings.

ITEM#	$	£	€	RMB	MAGNIFICATION	NA	EFL	WD	LENGTH
RMS4X	$ 175.40	£ 121.60	€ 155,80	¥ 1,481.10	4X	0.10	45 mm	18.5 mm	30.9 mm
RMS10X	$ 371.30	£ 257.40	€ 329,70	¥ 3,135.30	10X	0.25	18 mm	10.6 mm	38.8 mm
RMS20X	$ 430.40	£ 298.40	€ 382,20	¥ 3,634.40	20X	0.40	9 mm	1.2 mm	48.5 mm
RMS40X	$ 779.30	£ 540.30	€ 691,90	¥ 6,580.50	40X	0.65	4.5 mm	0.6 mm	48.8 mm



I.4. BOSA

now you see the light in real time

ARAGON PHOTONICS

Technical Specifications BOSA-C TS001_0102_0307

Optical Resolution (@3dB)	80fm (10MHz @1550nm)
Wavelength Range [1]	1528-1565nm
Span Range	1 pm to complete range
Wavelength Accuracy [1]	depends on TLS model
Dynamic Range	>80dB
Close-in Dynamic Range	>40dB @±0.33pm (filter width @ 40dB depth) >60dB @±0.44pm (filter width @ 60dB depth)
Power Range	+10 to -70dBm
Sensitivity [2]	-70dBm/0.1pm
Power Accuracy [3]	±1.5 dB
Maximum Safe Total Input	+20 dBm
Polarization Dependence [4]	±0.5 dB
Optical Input Test (SUT)	SMF; FC/APC (other on request)
Optical Input TLS (probe)	PMF panda type; FC/APC (other on request)
Power Requirement	100/110/220v, 50/60Hz
Measurement time	1s for 10nm
Maximum Power	120W
Dimensions (mm^3)	440x370x88
Weight	10 Kg
Operating Temperature	+15°C to +35°C
Advanced Functions	Spectral width, Total power integration, Power meter, Traces & Markers functionalities, Polarization control, Peak search, Ref. level search, Hold max/min, Averaging, Automeasure, Macro Editor Tool (Automated measurements)
Data storage	Hard disk and External USB storage File type: *.txt, *.csv, *.jpg Video recording:*.avi format
External Application	*BOSA Trace Viewer Application* to view and analyze traces

These specs are subject to change without further notice. Check the latest status in www.aragonphotonics.com.

1/2

Notes:

(1) Wavelength dependent figures such as accuracy or repeatability are determined by the TLS. The BOSA is only compatible with selected tunable lasers that assure the requested quality from the probe. Aragón Photonics recommends the selection of the best among them, depending on customer needs. Aragón Photonics recommends the periodical calibration of the TLS according to the advice of the manufacturer

(2) Sensitivity is defined as signal value > 6x RMS noise value, after averaging, polarization control and with *Lock Trace* on. This is given for a TLS probe with a dynamic relative power flatness of less than ±0.02 dB.

(3) Valid for any wavelength and power value (polarization dependence included). Valid for measurements made with polarization control, in high sampling rate mode and averaging.

(4) For 1σ (63 % of the cases). Typical value: ±1 dB.

Valid for software revision 1.1 or higher.

Anexo II
Software Monocromador

```
Dim lambda As Double

Private Sub espera(tiempo As Single) 'tiempo en segundos
   Dim tfinal As Single

   tfinal = tiempo + Timer
   If tfinal > 86400 Then
      While (Timer > 0.1): Wend
      tfinal = tfinal - 86400
   End If
   While (Timer < tfinal): DoEvents: Wend
End Sub

Sub inimonoc(lambda)
   Dim a, b As String
   Dim num As Double
   With Worksheets("Medida")

   If .ComMonoc.PortOpen = False Then
     .ComMonoc.PortOpen = True
   End If

   a = "  "
   .ComMonoc.Output = a
   espera (0.5)
   b = .ComMonoc.Input
   b = .ComMonoc.Input
   b = .ComMonoc.Input
```

```
    a = "E1"
    .ComMonoc.Output = a + Strings.Chr(13)
    espera (0.5)
    b = .ComMonoc.Input

    a = "V500"
    .ComMonoc.Output = a + Strings.Chr(13)
    espera (0.5)
    b = .ComMonoc.Input

    a = "F50,1"
    .ComMonoc.Output = a + Strings.Chr(13)
    espera (14)
    b = .ComMonoc.Input

    num = ((lambda + 44) * 4) + 8
    .ComMonoc.Output = "-" & CStr(num) & Strings.Chr(13)
    espera (12)
    b = .ComMonoc.Input
    End With
End Sub

Sub mueve_monoc(nmetros As Integer)
    Dim a, b As String
    If nmetros > 0 Then
        a = "-" + CStr(4 * nmetros)
    Else
        a = "+" + CStr(-4 * nmetros)
    End If
    Worksheets("Medida").ComMonoc.Output = a + Strings.Chr(13)
    espera (0.5)
    b = Worksheets("Medida").ComMonoc.Input
End Sub

Private Sub BucleMedida(M, N As Integer)

    If M = 1 Then
        col = 9
        If N = 1 Then
            d1 = 1: d2 = 2
        Else
            d1 = 1: d2 = 3
        End If
    Else
        col = 12
        If N = 1 Then
            d1 = 4: d2 = 5
        Else
            d1 = 4: d2 = 6
        End If
    End If
```

```
    channelNumber = Application.DDEInitiate(app:="LockinServer", topic:="lockin")

    With Worksheets("Medida")

    lambda = .Cells(4, col).value
    lambdafin = .Cells(5, col).value
    lambdainc = .Cells(6, col).value
    inimonoc (lambda)
    i = 9
    Do
        .Cells(i, d1).value = lambda
        .Cells(3, 2).value = midelockin(channelNumber)
        .Cells(i, d2).value = .Cells(3, 2).value
        lambda = lambda + lambdainc
        i = i + 1
        mueve_monoc (lambdainc)
        espera (0.5)
    Loop Until lambda > lambdafin
    End With
    Application.DDETerminate channelNumber
End Sub

Private Sub CommandButton1_Click()
    lambda = 1550
    inimonoc (lambda)
End Sub

Private Sub CommandButton2_Click()
    Dim inc_lambda As Double
    inc_lambda = Worksheets("Medida").Cells(3, 2).value - lambda
    mueve_monoc (inc_lambda)
    lambda = Worksheets("Medida").Cells(3, 2).value
End Sub

Private Sub CommandButton3_Click()
    Str1 = "Compruebe que:"
    Str2 = "1.- Se ha optimizado el acoplamiento de luz"
    MsgBox (Str1 + vbCrLf + Str2)
    Call BucleMedida(1, 1)
End Sub

Private Sub CommandButton4_Click()
    Str1 = "Compruebe que:"
    Str2 = "1.- No hay curvaturas en los 2 m. de fibra"
    MsgBox (Str1 + vbCrLf + Str2)
    Call BucleMedida(1, 2)
End Sub

Private Sub CommandButton5_Click()
    Str1 = "Compruebe que:"
    Str2 = "1.- Ha realizado un bucle de 28 cm"
    MsgBox (Str1 + vbCrLf + Str2)
```

```
   Call BucleMedida(2, 1)
End Sub

Private Sub CommandButton6_Click()
   Str1 = "Compruebe que:"
   Str2 = "1.- Ha realizado un bucle de 6 cm"
   MsgBox (Str1 + vbCrLf + Str2)
   Call BucleMedida(2, 2)
End Sub
```

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