

# GSOLVER© V5.1 Diffraction Grating Analysis Program

**Default Parameter Values**

Vacuum Wavelength: 0.7472 microns    Microns    UNITS Selection

Grating Period: 1.25 microns    1 conversion (from microns) factor

or Lines/mm: 800    Superstrate Index: select (1.00000, 0.00000)

Substrate Index: select (1.65521, 0.00000)

Angles of Incidence  
THETA: 20  
PHI: 0

POLARIZATION  
ALPHA: 0  
BETA: 0  
or Stokes Parameters  
S1: 1.000000  
S2: 0.000000  
S3: 0.000000

**View**

	-3R	SumR	2T
0	0.217512514	0.185787638	
0	0.188817491	0.213652092	
0	0.160936683	0.245161666	
0	0.133605093	0.278722247	
0	0.1101086	0.289032127	
0	0.125540491	0.262177179	
180	0.143841167	0.232213133	
710	0.165089783	0.203025853	
806	0.185164288	0.178300742	
827	0.203266816	0.159707427	
657	0.219528642	0.14725529	
689	0.233590804	0.14029315	
560	0.210613155	0.176953418	
558	0.216346234	0.174910567	
373	0.321733788	0	
744	0.380114401	0	
696	0.391284121	0	
894	0.386756543	0	
058	0.376636768	0	
38.000	0.143673752	0.160160836	0.061873710
40.000	0.126887571	0.171266518	0.057731816
42.000	0.113645562	0.181196756	0.052832361
44.000	0.102706573	0.190810106	0.04743733
46.000	0.093008695	0.200694965	0.041652816

## Principle Features

- Full 3D vector solution (with choice of solution method)
- Arbitrary polarization including TE, TM, Elliptical
- Conical mounts
- Arbitrary number of index changes per level
- Arbitrary number of grating levels
- Calculation of complex vector E-fields
- Powerful graphical grating structure editor
- Material catalogs and editor
- Optimized partitioned matrix calculations
- Multiple graphical, data spreadsheet, and text windows
- Genetic algorithm based automatic design
- Arbitrary algebraic constraints
- Diffraction angles calculation tool
- Diffracted order phase calculation
- 128 and 256 bit floating point arithmetic

Grating Solver Development  
Company

P.O. Box 353 - Allen, TX 75013  
USA

(972)727-8008 (Voice/FAX)

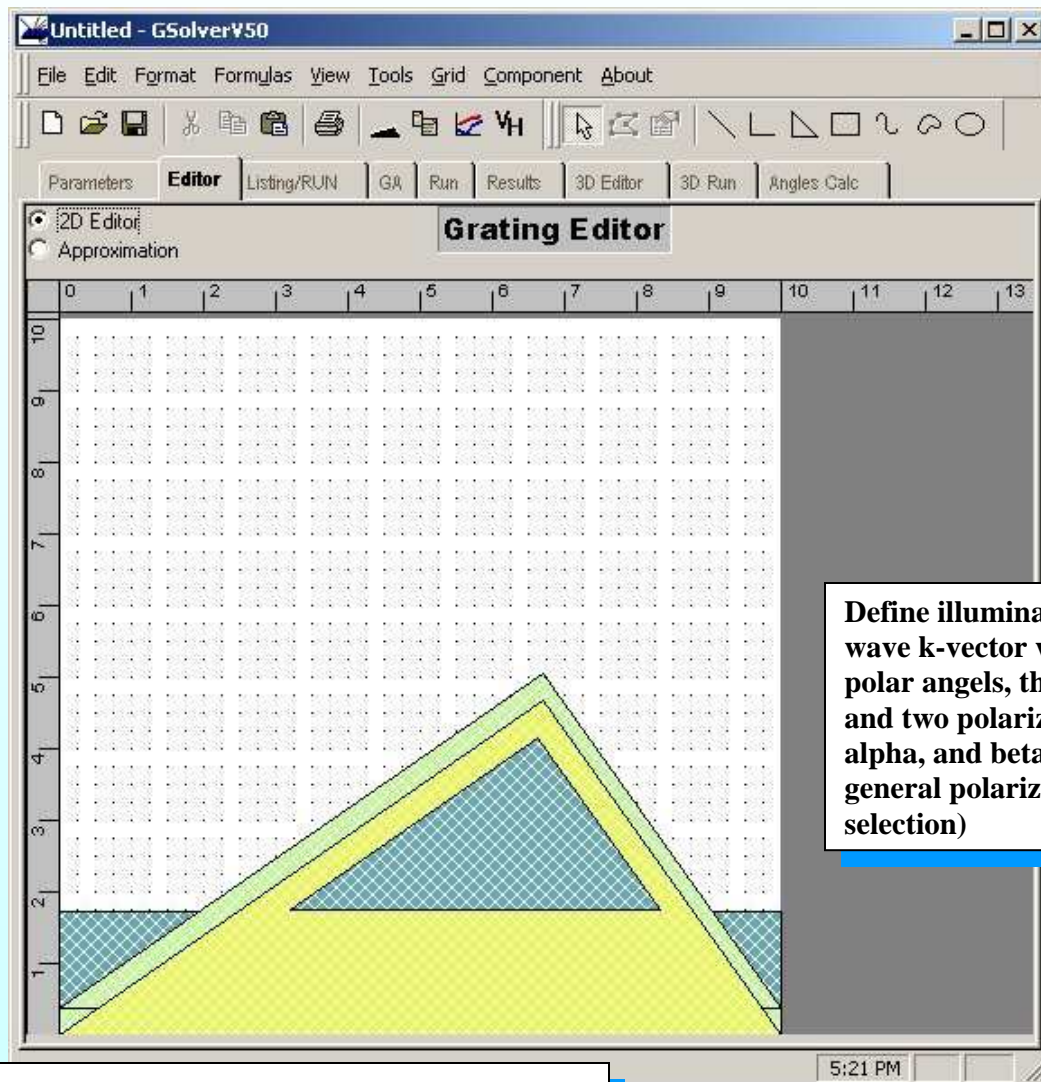
<http://www.gsolver.com>

# GSOLVER© V5.1 Graphical Grating Editor

## Draw arbitrary profiles

- Tools for classical profiles
- Draw structure on unit cell
- Palette of graphical primitives
- Assign material properties

- Automatic piecewise constant approximation
- Drag and Drop graphical primitives
- OLE container for Microsoft Office products



Define illumination, plane wave k-vector with two polar angles, theta, and phi, and two polarization angles, alpha, and beta (this permits general polarization selection)

## Refractive Index Catalog -

- Nobel Metals (Drude Model)
- Glass Catalogs (Schott, Corning, Hoya, O'Hara)
- IR Materials (Sellmeier, Herzberger)
- 9th order polynomial (real and image)
- Table look-up
- Graphical coefficient editor

- Transverse, and crossed grating structures are fully supported
- General polarization, and angle of incidence including conical mounts

# GSOLVER© V5.1 Flexible Execution Control

**General Algebraic Parameter Entry**

- Enter arbitrary algebraic expression with constraints for parameter variation

The screenshot displays the GSOLVER V5.1 interface. The main window is a spreadsheet titled 'Untitled - GSolverV50'. The spreadsheet is organized into columns A through E. Column A contains parameter names, column B contains values or formulas, and columns C through E contain control options for a 'Free Parameter'.

Row	Parameter	Value/Formula	Control	Control	Control
2	'Theta:	=D5			
3	'Phi:	0			
4	'Alpha:	0	'Current	'Increment	'Stop
5	'Beta:	0	3	1	100
6	'wavelengt	0.7472			
7	'Period:	=1+SIN(D5/100)	Update	Decrement	Increment
8	'Superstrat	'Ones			
9	'Substrate:	'AL2O3	RUN		Populate
10	'Orders:	3			
11	'LAYER '1			0 %	
12	'Thickness	0.025	=B12		
13	'Block:	'1	Abort		<input type="checkbox"/> Write Field
14	'Width:	0.025	=B14		
15	'Material:	'Si3N4			
16	'Block:	'2			
17	'Width:	0.975	=B14+B17		
18	'Material:	'AL2O3			
19	'LAYER '2				
20	'Thickness	0.025	=B12+B20		
21	'Block:	'1			

The 'chart: 2' window shows a line graph of Diffraction Efficiency versus Theta. The x-axis ranges from 0.00 to 88.00, and the y-axis ranges from 0.00 to 0.30. Three data series are plotted: 1R (blue squares), -1R (green circles), and -2R (red triangles). The -1R series shows a prominent peak at approximately 66 degrees.

The 'View' window displays a table of results:

	-3R	SumR	2T
	0.217512514	0.185787638	0
	0.188817491	0.213652092	0
	0.160936683	0.245161666	0
	0.133605093	0.27872247	0
	0.1101086	0.289032127	0
	0.125540491	0.262177179	0
	0.143841167	0.232213133	0
	0.165089783	0.203025853	0
	0.185164288	0.178300742	0
	0.203266816	0.159707427	0
	0.219528642	0.14725529	0
	0.233590804	0.14029315	0
	0.210613155	0.178953418	0
	0.216346234	0.174910567	0
	0.321733788	0	0
	0.380114401	0	0
	0.391284121	0	0
	0.386756543	0	0
	0.376636768	0	0
	0.365708298	0	0
	0.355885906	0	0
	0.34767468	0	0
	0.340954009	0	0
	0.335356477	0	0

**GSOLVER V5.1 features optimized algorithms that solve the full vector Maxwell equations in the grating region. Arbitrarily complex grating structures made of an arbitrary number of materials specified by piecewise constant model. The algorithm is based on a 'Rigorous Coupled Wave' method using Stack matrix methods to solve for the interlayer boundary conditions. Specializations are used to speed convergence for arbitrary polarization. Optimizations for TE and TM polarization modes are also included.**

# GSOLVER© V5.1 Differential Evolution

The screenshot shows the GSolverV50 application window. The spreadsheet contains the following parameters:

	A	B	C
1	GA Grad		
2	Theta:	20	
3	Phi:	0	
4	Alpha:	0	
5	Beta:	0	0 1.3 0.7119140625
6	wavelength	0.7472	-2.1 124.5 0.1624145508
7	Period:	1.25	0 1 0.3136901855
8	Superstrat	Ones	
9	Substrate:	AL2O3	
10	Orders:	3	
11	LAYER 1		
12	Thickness	0.025	0.025
13	Block:	1	
14	Width:	0.025	
15	Material:	SI3N4	
16	Block:	2	
17	Width:	0.975	
18	Material:	AL2O3	
19	LAYER 2		
20	Thickness	0.025	0.05
21	Block:	1	
22	Width:	0.05	
23	Material:	SI3N4	
24	Block:	2	
25	Width:	0.925	
26	Material:	AL2O3	

The GA control panel includes buttons for RUN GA, Populate, Abort, GA test, and Options.

## Genetic Algorithm Optimization

- Enter arbitrary algebraic constraint expressions
- Arbitrary number of control parameters
- Multiple diffraction efficiency goals
- Multiple evolution strategies
- Full Differential Evolution option control

The dialog box is titled "Genetic Algorithm Settings/Differential Evolution". It contains the following settings:

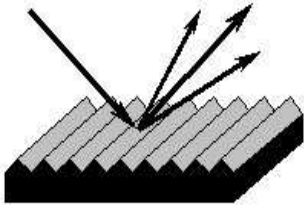
- Population: 25 (nominally 10x total number of parameters)
- Weight: 0.7 (nominally = 0.8 (0 < F <= 1), larger values => faster convergence)
- Cross-over: 0.3 (nominally = 0.9 (0 <= CR <= 1))
- Max Iterations: 25 (Stopping criterial)
- Number of Real Parameters: 3

Goal settings for selected orders:

Order	Goal	Weight
1R	0.75	1
-1T	0.25	1

Select differential solution mode:

- "Rand1Bin"
- "Best1Exp"
- "Rand1Exp"
- "RandToBest1Exp"
- "Best2Exp"
- "Rand2Exp"
- "Best1Bin"
- "Rand1Bin"
- "RandToBest1Bin"
- "Best2Bin"
- "Rand2Bin"



## Grating Solver Development Company

P.O. Box 353  
Allen, Texas 75013  
FAX/Voice (972) 727-8008  
<http://www.gsolver.com>  
[gsolver@gsolver.com](mailto:gsolver@gsolver.com)

Dear Diffraction Grating Designer,

Thank-you for your interest in GSOLVER. A fully functional demo version of the GSOLVER program is available free. The download site is <http://www.gsolver.com/thanks.htm>.

The demo program does not support file I/O (you cannot save grating structure files or results). It is also limited to a total of ten layers in the piecewise constant approximation. There are several example calculations in the users manual (download from the web site). If you have questions about GSOLVER please FAX, or e-mail them and you will receive a prompt response.

GSOLVER may be used to reproduce numerous rigorous diffraction calculations published in the literature. A few (among many) literature examples are

1. M.G. Moharam, T.K. Gaylord, 'Diffraction analysis of dielectric surface-relief gratings,' JOSA 72, 1385(82).
2. L. Li, 'Multilayer modal method for diffraction gratings of arbitrary profile, depth, and permittivity,' JOSA -A 10, 2581(93).
3. L. Li, C.W. Haggans, 'Convergence of the coupled-wave method for metallic lamellar diffraction gratings,' JOSA-A 10, 1185(93).
4. T.K. Gaylord, W.E. Baird, M.G. Moharam, 'Zero-reflectivity high spatial-frequency rectangular-groove dielectric surface-relief gratings,' Apl. Opt. 25, 4562(86).
5. M.G. Moharam, T.K. Gaylord, 'Rigorous coupled-wave analysis of metallic surface-relief gratings,' JOSA-A 3, 1780(86).
6. T.K. Gaylord, M.G. Moharam, 'Analysis and Application of Optical Diffraction by Gratings,' Proc of the IEEE 73, 894(85).
7. E.G. Loewen, M. Neviere, D. Maystre, 'Grating efficiency theory as it applies to blazed and holographic gratings,' Apl.Opt. 16,2711(77).

See also:

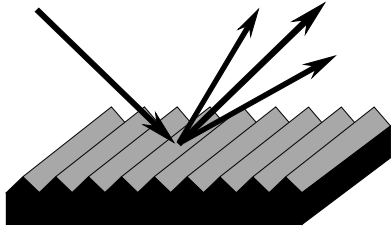
- B.E. Popov, L. Tsonev, D. Maystre, 'Lamellar metallic grating anomalies,' Apl. Opt. 33, 5214 (94).  
T. Glaser, S. Schroter, H. Bartelt, H. Fuchs, E. Kley, 'Diffractive optical isolator made of high-efficiency dielectric gratings only,' Applied Optics, Vol. 41, No. 18/20 June 2002.

S.C. Barden, J.A. Arns, W.S. Colburn, J.B. Williams, 'Volume-Phase Holographic Gratings and the Efficiency of Three Simple VPH Gratings,' Publications of the Astronomical Society of the Pacific, June 2000. (NOAO Preprint No 869)

See IEEE Spectrum June 1998 issue for a review of GSOLVER in 'Software Reviews'.

GSOLVER is based on a full vector implementation of rigorous coupled wave theory. This reduces the solution of (the interlayer) Maxwell equations to an algebraic eigenvalue problem. The intralayer boundary conditions are solved using Stack-matrix methods. Application of the piecewise constant approximation to the grating region permits arbitrary grating structure realization. Calculations are limited by 64bit floating point accumulations of the Intel hardware, and the truncation order parameter.

Sincerely,  
David Fluckiger



**Grating Solver Development Co.**  
**P.O. Box 353**  
**Allen, TX 75013**  
**Voice/Fax (972)727-8008**  
**<http://www.gsolver.com>**  
**[gsolver@gsolver.com](mailto:gsolver@gsolver.com)**

## **Price List for GSOLVER**

<b>GSOLVER V5.1</b> (for Windows OS)	<b>\$3295.00</b>
<b>Shipping and Handling</b>	<b>\$ 20.00 (Domestic)</b> <b>\$ 65.00 (International)</b>
<b>One year subscription for technical support and upgrade</b>	<b>\$ 300.00</b>

**GSOLVER V5.1 is a full 32-bit integrated executable for Windows OS. GSOLVER is dongle protected (USB key with single user license).**

**Customers are responsible for any duties and taxes. Texas customers must add applicable state sales tax (8.25%). All orders F.O.B. Allen, Texas, U.S.A.**

**We generally ship within two business days of receipt of Purchase Order.**

**We do not accept credit cards.**

**We are a small business**

**Please supply shipping and billing address and Technical Point of Contact**