NIF Grating Debris Shield (GDS): diffraction efficiency, E fields, heating modeled with COMSOL

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COMSOL Multiphysics @ LLNL 14 seats compared to Gsolver one physics & key.

Wave Optics Modeling by Ulf Oli workshop https://www-eng-i.llnl.gov/llnl_only/estk/download/comsol/docs/2019.03.01_Workshop/Wave_Optics_Modeling_LLNL.pdf

Get background on computational methods via

The University of Texas at El Paso | College of Engineering

Lectures by Professor Raymond Rumpf EE 5337

COMPUTATIONAL ELECTROMAGNETICS *rcrumpf@utep.edu*

CEM Lectures Published on Sep 21, 2013

https://www.youtube.com/watch?v=mOy5jyZe7_Y

COMSOL Multiphysics study of National Ignition Facility (NIF) GDS.

Started with online example:

https://www.comsol.com/model/diffraction-grating-19083

Attend LLNL workshops, archived https://www-eng-i.llnl.gov/llnl_only/estk/download/comsol/docs/

Organized / Maintained by Nelson, Scott D. <nelson18@llnl.gov>

M. G. Moharam and T. K. Gaylord Vol. 71, No. 7/July 1981/J. Opt. Soc. Am. 811

Rigorous coupled-wave analysis of planar-grating diffraction

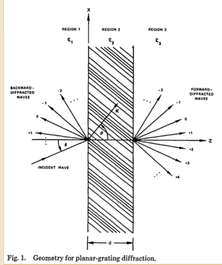


Fig. 1. Geometry for planar-grating diffraction.

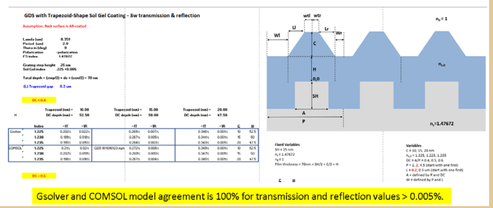
$$E_1 = \exp[-j(\beta_{0x}x + \xi_{10}z)] + \sum_i R_i \exp[-j(\beta_i x - \xi_{1i}z)], \quad (2)$$

$$E_3 = \sum_i T_i \exp[-j[\beta_i x + \xi_{3i}(z-d)]], \quad (3)$$

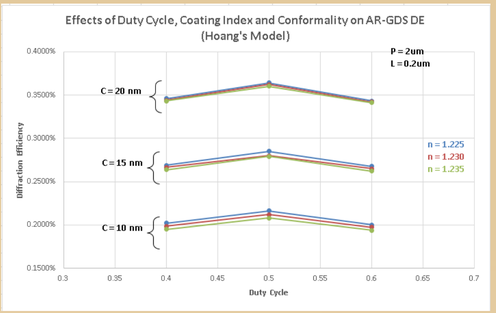
$\bar{R}_i$ is the normalized amplitude of the ith reflected wave and is to be determined from the matching of the electric and magnetic fields.

COMSOL & Gsolver models Compared

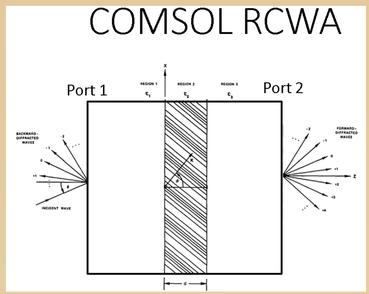
Gsolver and COMSOL GDS 1811090123.mph models agreement when DC = 0.4



Gsolver and COMSOL model agreement is 100% for transmission and reflection values > 0.005%.



COMSOL RCWA



COMSOL Diffraction Efficiency Calculation

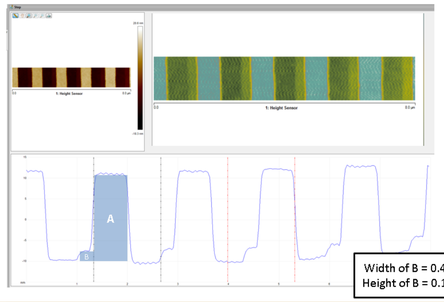
- On each Port boundary

$$\mathbf{E}(\mathbf{r}) = \sum_{i=1}^{N}\left(S_{ik}\exp(-j\beta_i\hat{\mathbf{n}}\cdot\mathbf{r}) + \delta_{ik}\exp(j\beta_i\hat{\mathbf{n}}\cdot\mathbf{r})\right)\mathbf{E}_i(\mathbf{r}),$$

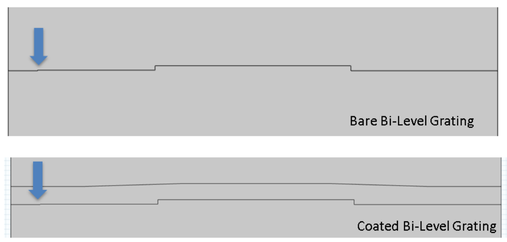
$$\mathbf{E_i}(\mathbf{r}) = \mathbf{A}\exp(-j\mathbf{k}_{\parallel}\cdot\mathbf{r})$$

AFM driven modeling & Data fitting

Bi-Level Grating Modeled Using Two Rectangles

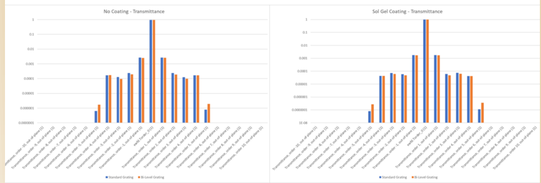


Bi-Level Grating



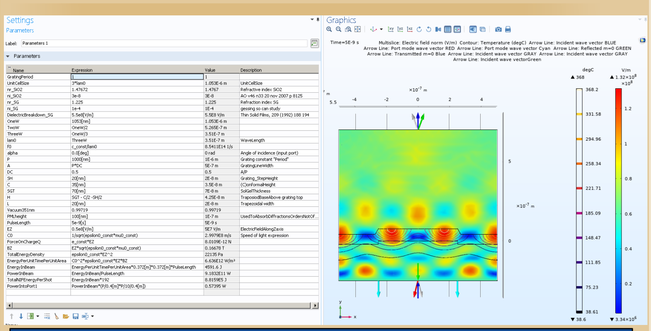
- Assumption: the bi-level shoulder is small and does not affect the overall conformality of the sol gel coating

Transmittance

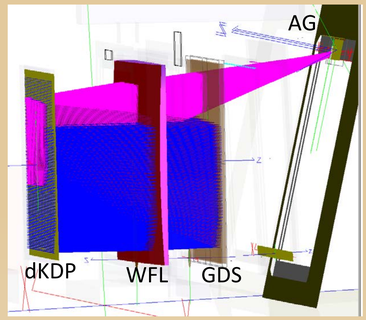


- The bi-level grating in both the coated and non-coated configurations does not significantly change the reflectance and transmittance when compared to the standard grating

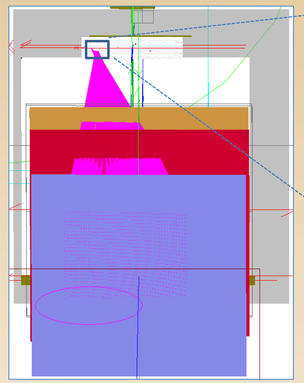
Explore E Field & thermal physics

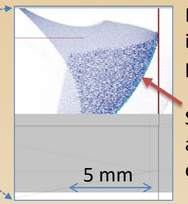


Study GDS SolGel modeled material properties , verify affect on scattered light paths with "Fred" ray tracing.



Modeled irradiance by 'pink' rays is a caustic focusing on Absorbing Glass(AG), the GDS diffraction efficiency values are studied. This caustic can burn the AG if the SolGel coatings change with usage.

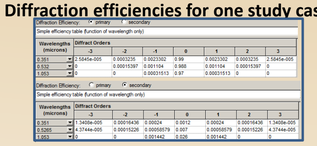




Ray caustic irradiance pattern

Scorched along edge

COMSOL GDS modeled Diffraction efficiencies for one study case



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