Photoeleastic Modulation in MgF_2 films

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Concept

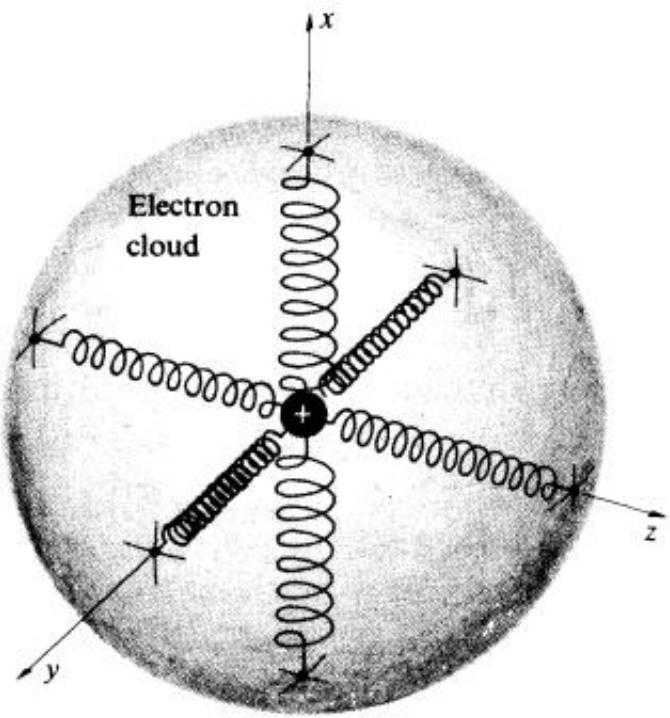


Figure 8.14 Mechanical model depicting a negatively charged shell bound to a positive nucleus by pairs of springs having different stiffness.

Optics, E.Hecht (fourth edition)

$$n^2(\omega) = 1 + \frac{Nq_e^2}{\epsilon_0 m_e} \sum_j \left(\frac{f_j}{\omega_{0j}^2 - \omega^2} \right)$$

- Stress decreases with increase in natural frequency.

- This means that a large effective spring constant (i.e., strong binding) corresponds to a low polarizability, a low dielectric constant, and a low refractive index.

- Similarly, if stiffness is isotropic (hypothetically), when electric field of incident light is along the direction of higher principal stress, natural frequency of electron vibration is higher and hence refractive index is higher.

Model 1 Inputs

- Refractive index (N)
- Young's Modulus (138.5 Gpa)
- Poisson's Ratio(0.276)
- Stress Optical Coefficients (B1,B2)=(0.65e-12 m^2/N, 4.2e-12 m^2/N)

$$n^2 - 1 = \frac{0.48755108\lambda^2}{\lambda^2 - 0.04338408^2} + \frac{0.39875031\lambda^2}{\lambda^2 - 0.09461442^2} + \frac{2.3120353\lambda^2}{\lambda^2 - 23.793604^2}$$

Equations Used

$$N_x = N - B1 * \sigma_x - B2 * (\sigma_y + \sigma_z)$$

$$N_y = N - B1 * \sigma_y - B2 * (\sigma_z + \sigma_x)$$

$$N_z = N - B1 * \sigma_z - B2 * (\sigma_x + \sigma_y)$$

Model 2 Inputs

- New Refractive Indices from model 1

Equations Used

$\nabla^2 E + k^2 E = 0$

S= (E x H)

I=<S>

R=I_r/I_i

T=I_t/I_i

$$r_s = \frac{n_1 \cos\theta_{\text{incident}} - n_2 \cos\theta_{\text{transmitted}}}{n_1 \cos\theta_{\text{incident}} + n_2 \cos\theta_{\text{transmitted}}}$$

$$t_s = \frac{2 n_1 \cos\theta_{\text{incident}}}{n_1 \cos\theta_{\text{incident}} + n_2 \cos\theta_{\text{transmitted}}}$$

$$r_p = \frac{n_2 \cos\theta_{\text{incident}} - n_1 \cos\theta_{\text{transmitted}}}{n_1 \cos\theta_{\text{transmitted}} + n_2 \cos\theta_{\text{incident}}}$$

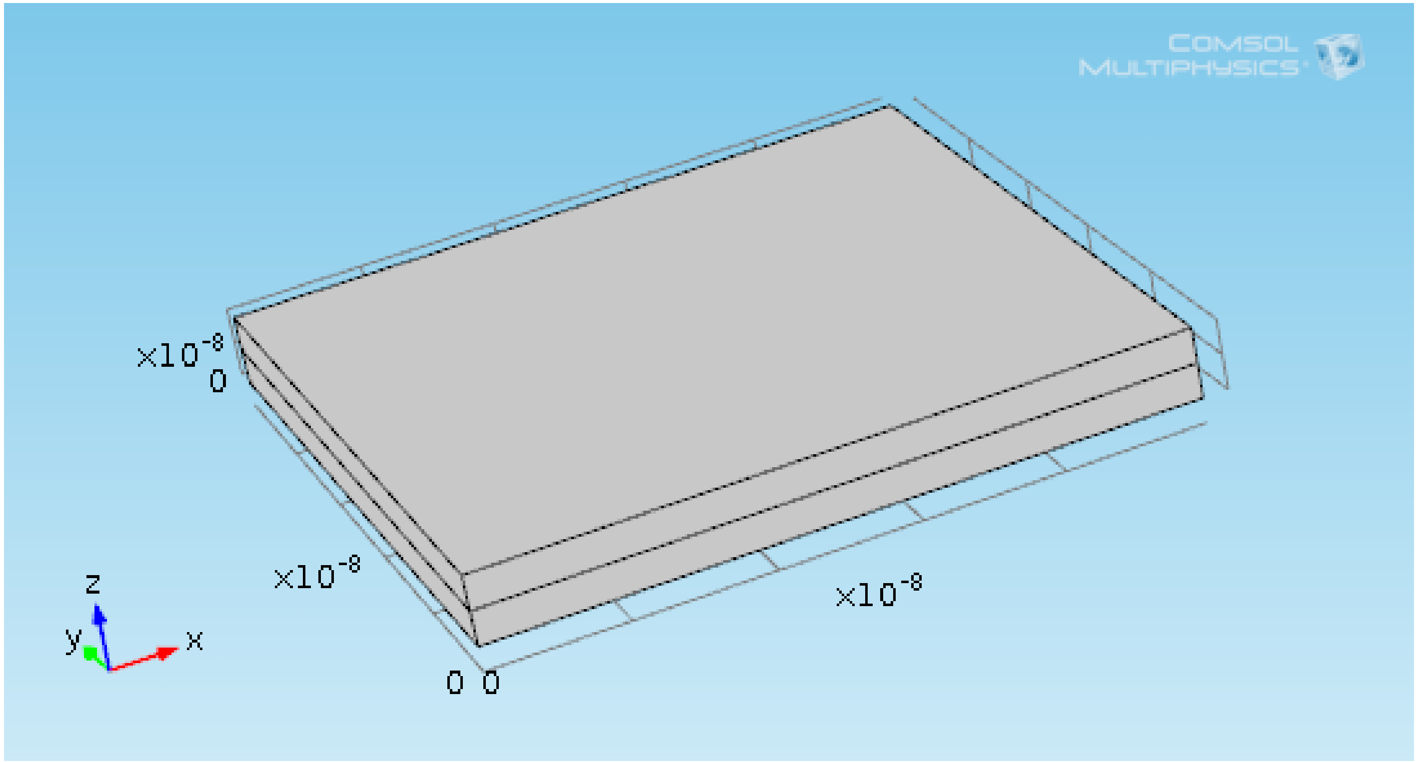
$$t_p = \frac{2 n_1 \cos\theta_{\text{incident}}}{n_1 \cos\theta_{\text{transmitted}} + n_2 \cos\theta_{\text{incident}}}$$

$$R = |r|^2$$

$$T = \frac{n_2 \cos\theta_{\text{transmitted}}}{n_1 \cos\theta_{\text{incident}}} |t|^2$$

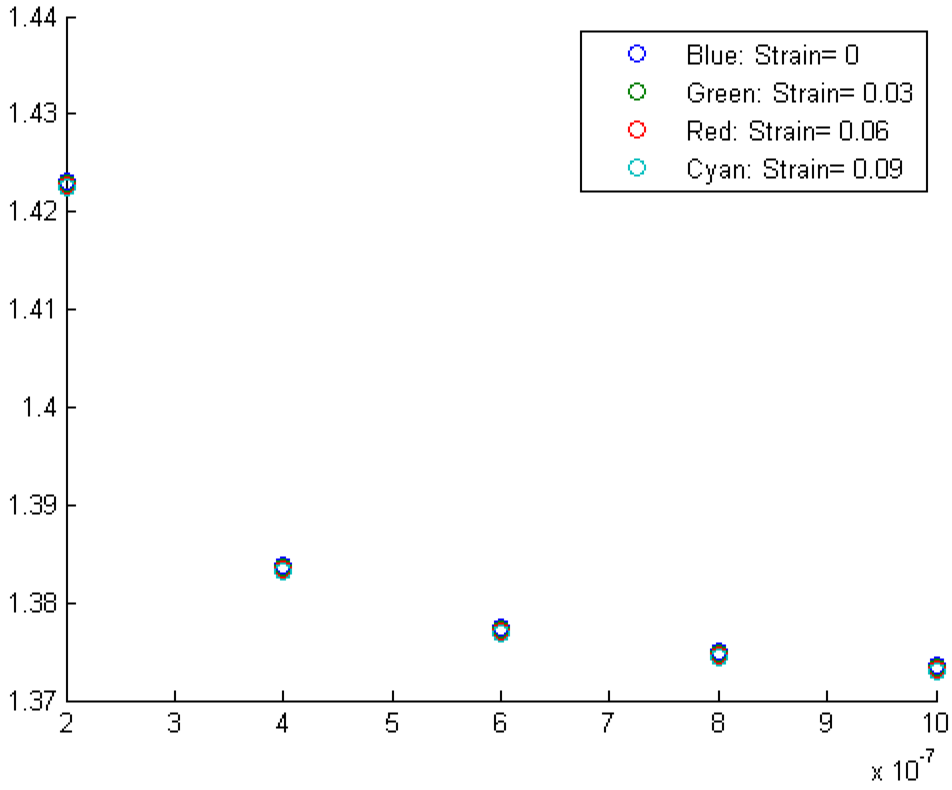
$$\theta_B = \text{atan}\frac{n_2}{n_1}$$

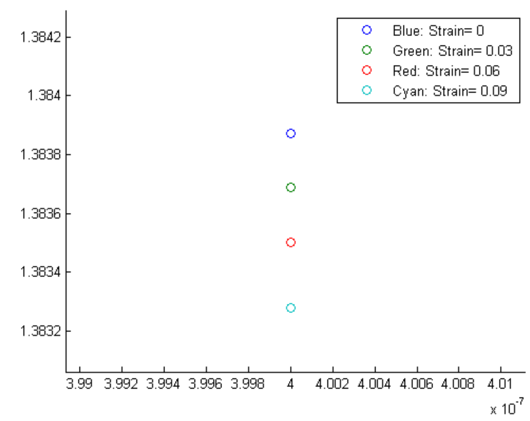
Model



Results

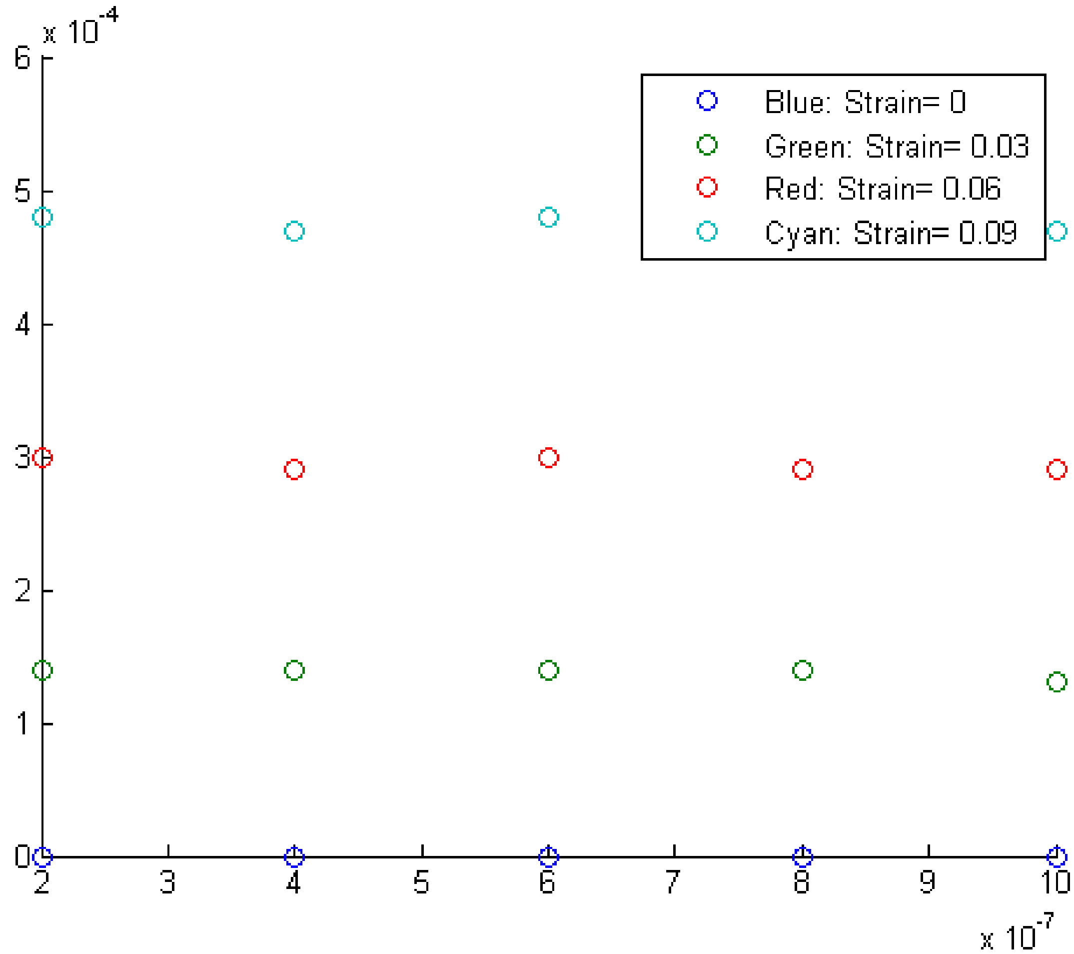
Nz





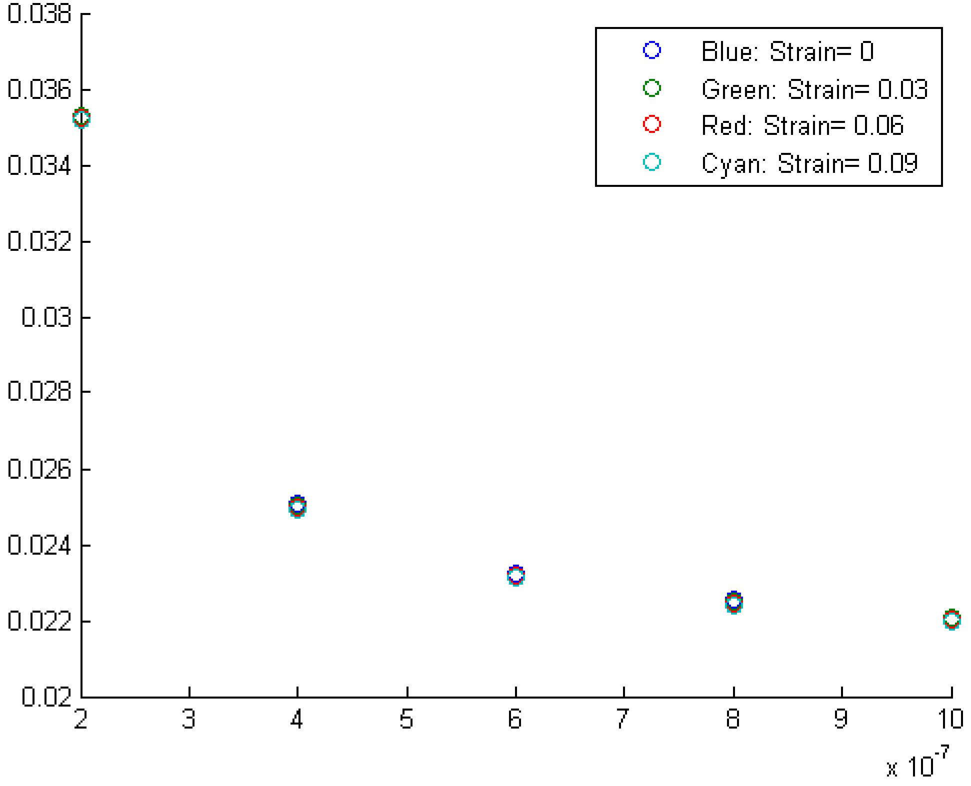
Wavelength(in m)

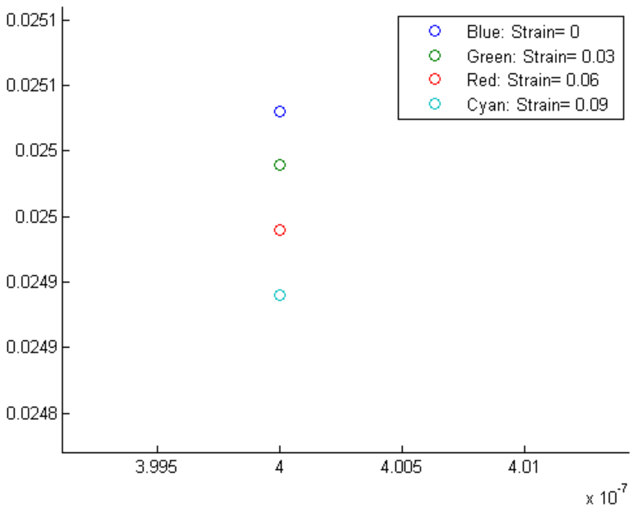
Nx-Ny



Wavelength(in m)

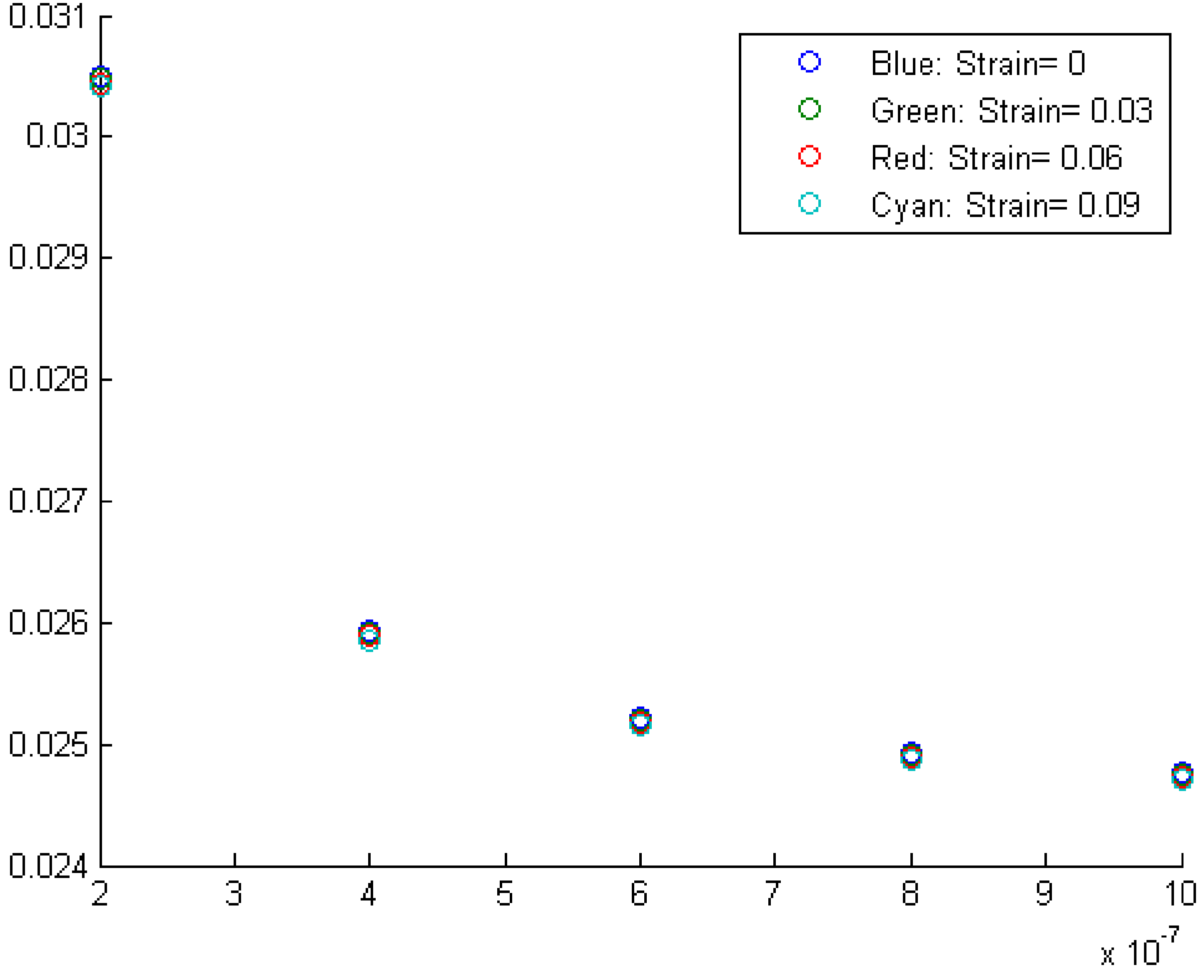
Reflectance(model)





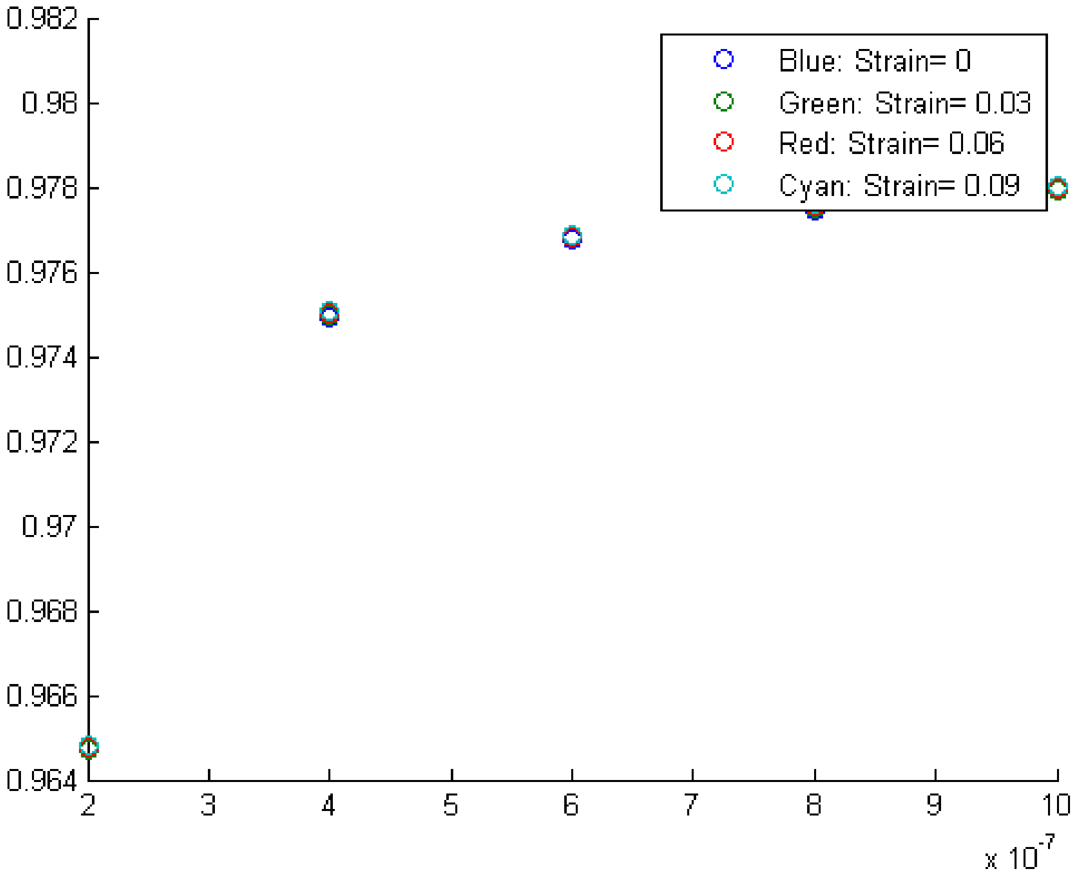
Wavelength(in m)

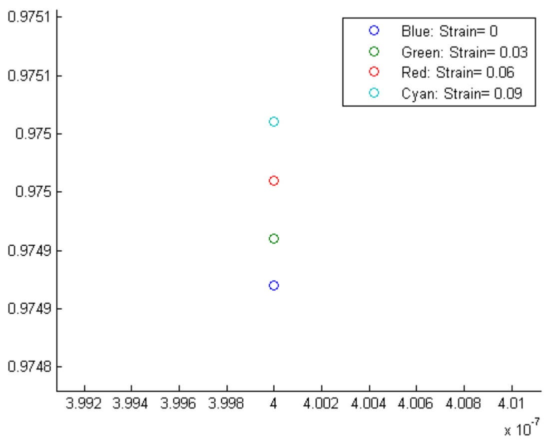
Reflectance(Analytical)



Wavelength(in m)

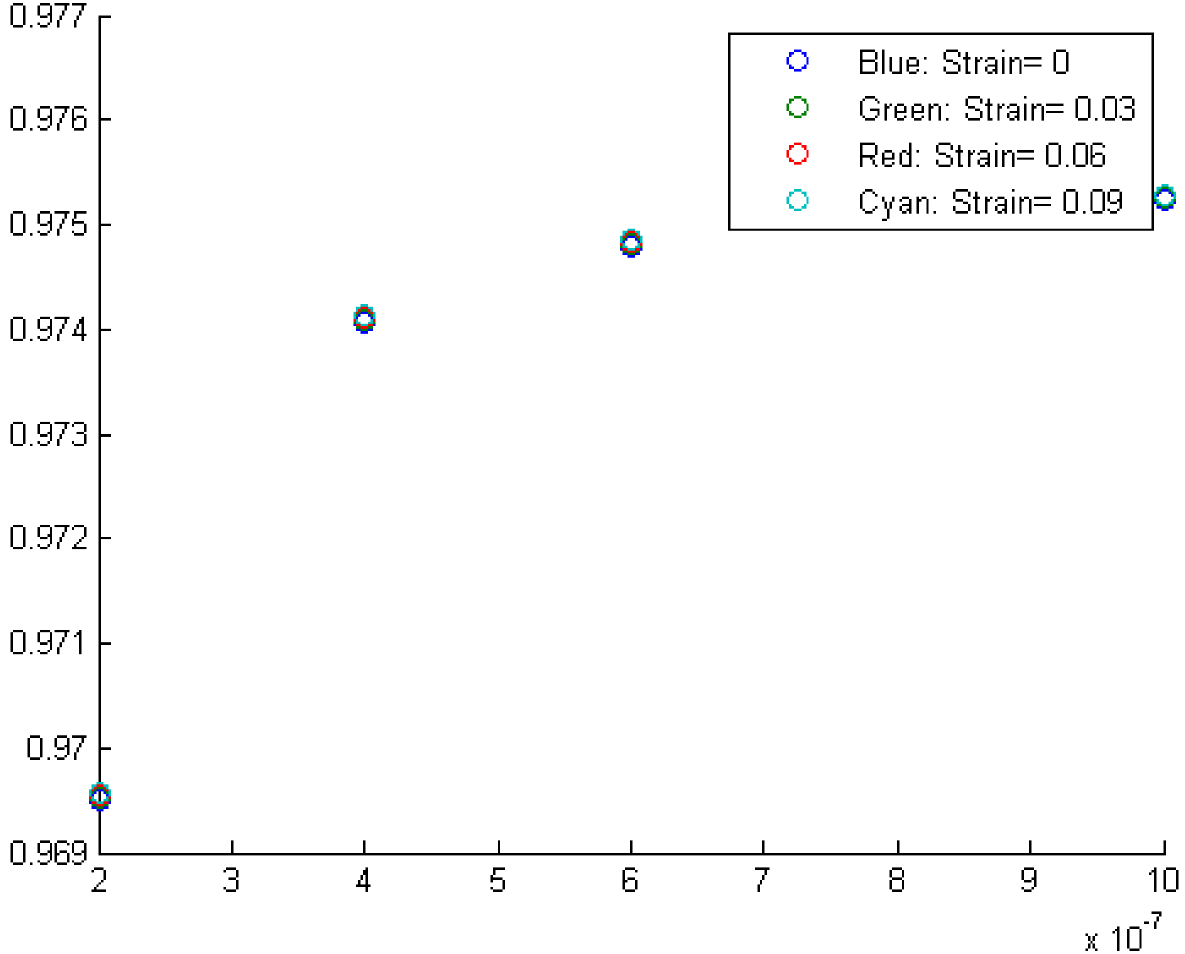
Transmittance(model)





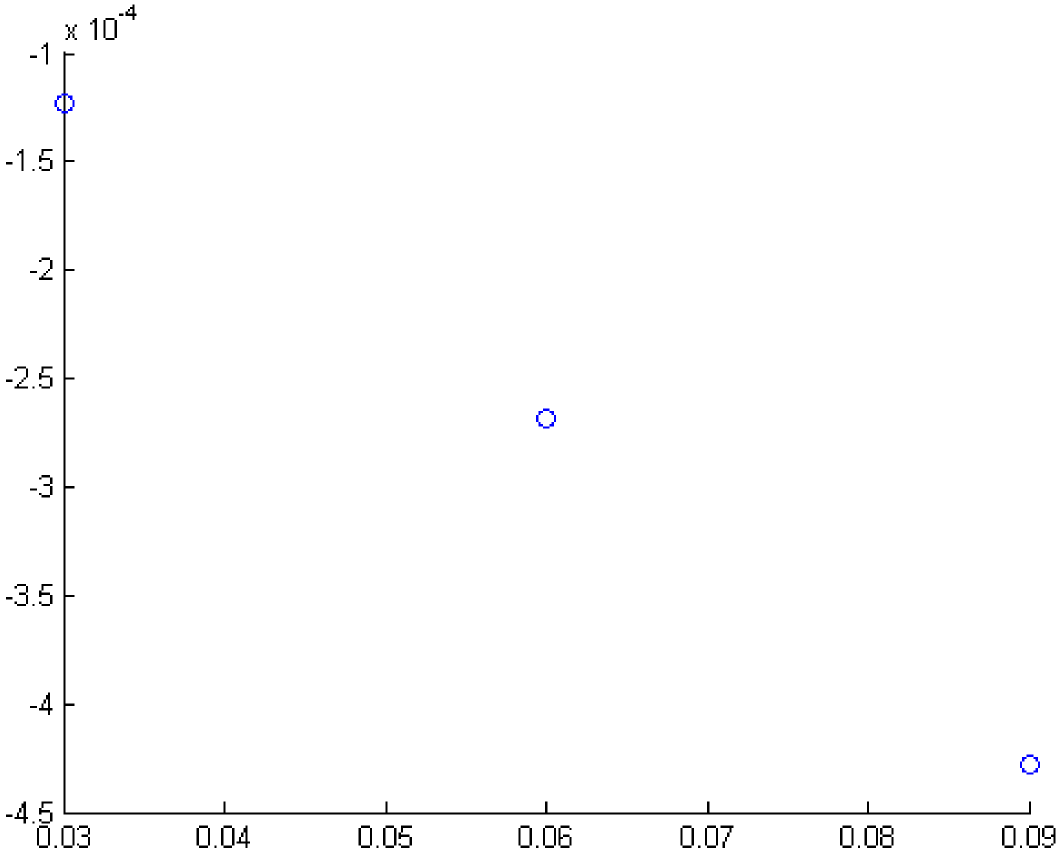
Wavelength(in m)

Transmittance(Analytical)



Wavelength(in m)

Relative change in Nz



Strain

Sources

- http://refractiveindex.info/?shelf=main&book=MgF2&page=Dodge-o
- http://www.almazoptics.com/MgF2.htm