<table>
<thead>
<tr>
<th><strong>Title</strong></th>
<th>Material kinetics during fabrication of holographic gratings in acrylamide-based photopolymer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Authors(s)</strong></td>
<td>Close, Ciara E.; Kelly, John V.; Gleeson, M. R.; O'Neill, Feidhlim T.; Sheridan, John T.</td>
</tr>
<tr>
<td><strong>Publication date</strong></td>
<td>2005-10-16</td>
</tr>
<tr>
<td><strong>Publication information</strong></td>
<td>Frontiers in Optics, OSA Technical Digest Series</td>
</tr>
<tr>
<td><strong>Conference details</strong></td>
<td>Paper presented at Frontiers in Optics (FiO), Tucson, Arizona, October 16, 2005</td>
</tr>
<tr>
<td><strong>Publisher</strong></td>
<td>Optical Society of America</td>
</tr>
<tr>
<td><strong>Link to online version</strong></td>
<td><a href="http://www.opticsinfobase.org/abstract.cfm?URI=FiO-2005-JWA58">http://www.opticsinfobase.org/abstract.cfm?URI=FiO-2005-JWA58</a></td>
</tr>
<tr>
<td><strong>Item record/more information</strong></td>
<td><a href="http://hdl.handle.net/10197/3474">http://hdl.handle.net/10197/3474</a></td>
</tr>
<tr>
<td><strong>Publisher's statement</strong></td>
<td>This paper was published in Frontiers in Optics and is made available as an electronic reprint with the permission of OSA. The paper can be found at the following URL on the OSA website: <a href="http://www.opticsinfobase.org/abstract.cfm?uri=FiO-2005-JWA58">http://www.opticsinfobase.org/abstract.cfm?uri=FiO-2005-JWA58</a>. Systematic or multiple reproduction or distribution to multiple locations via electronic or other means is prohibited and is subject to penalties under law.</td>
</tr>
</tbody>
</table>
Material Kinetics during Fabrication of Holographic Gratings in Acrylamide-based Photopolymer

Ciara E. Close, John V. Kelly, Michael R. Gleeson, Feidhlim T. O’Neill, John T. Sheridan
Department of Electronic and Electrical Engineering, University College Dublin, Belfield, Dublin 4, Ireland
Contact author: john.sheridan@ucd.ie

Abstract: We describe holographic grating formation in Acrylamide-based photopolymer material using the Non-Local Diffusion Driven model & discuss radical suppression leading to an inhibition period before grating growth. Diffusion effects of monomer & polymer are discussed.

OCIS codes: (050.7330); (210.4810)

1. Introduction
A more thorough understanding of the Acrylamide-based photopolymer material kinetics during and after holographic recording is necessary to further facilitate the evolution of holographic data storage systems. To this end, experiments are carried out and using the results obtained, values for the diffusion constant are calculated.

The diffusion effects in the photopolymer material during and post-exposure are modeled using the Nonlocal Polymer Driven Diffusion (NPDD) model. Using the value obtained for the diffusion constant, the evolution of the Acrylamide monomer and Polyacrylamide concentration are modeled.

The model accounts for the existence of an inhibition period prior to the onset of diffraction of the replay beam. This period is attributed to the presence of Oxygen within the material, which results in the termination of the Polyacrylamide chains before they grow large enough to cause a significant density variation in the material.

2. Diffusion Constant
The grating is recorded using a standard holographic setup. From the results obtained and using Kogelnik’s coupled wave theory, a value for $\alpha$, the decay constant of the grating refractive index modulation is found. From this, using Ficks’s Law, a value for the diffusion constant is found. The impact of the crosslinker concentration affects the rate of decay of the grating and hence the diffusion constant.

3. NPDD Model
The NPDD model is based on a 1-D diffusion equation utilizing Fick’s Law.

$$\frac{\partial u(x,t)}{\partial t} = \frac{\partial}{\partial x} \left[ D(x,t) \frac{\partial u(x,t)}{\partial x} \right] - \int_0^\infty \int_0^\infty R(x,x',t,t') F(x',t') \left[ \frac{u(x,t)}{u(x,t) + N(x,t)} \right]^\beta dt' dx' - \frac{u(x,t)}{u(x,t) + N(x,t)} \frac{\partial H(x,t)}{\partial t} \tag{1}$$

where $u(x,t)$ is the free-monomer concentration, $D(x,t)$ is the diffusion constant, $F(x,t)$ is the polymerization rate, $N(x,t)$ is the polymer concentration, $R(x,x',t,t')$ is the nonlocal material response function, and $H(x,t)$ is the hole concentration.

4. Inhibition Effects
The ‘dead-band’, which can be seen at the initial stages of grating growth, has been modeled by a step function. Experiments were carried out to observe the effects caused by inhibitors such as oxygen and the inclusion of these effects have been added to our model. Equation 2 shows the polymerization rate with the inclusion of the step-function.

$$F(x,t) = f_0 \theta \left[ \frac{U_0}{l_d} - \rho(t) \right] \left[ 1 + V \cos(Kx) \right] \tag{2}$$

References: