POLYMERS FOR OPTOELECTRONIC APPLICATIONS

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Organic synthetic polymers are emerging as key materials for advanced information and communication technology. Due to their structural flexibility and low cost, polymers are expected to play a major role in optical technology especially when large volume manufacturing at low cost is crucial. Among multifunctional polymers, amorphous organic photorefractive polymers have emerged recently.[1-6] The rapid improvement of the performance of photorefractive polymers over the past five years has generated a strong technological interest for these new materials. They have reached a performance level[2] that competes with that of inorganic photorefractive crystals that have been studied for three decades. These results demonstrate the high potential of polymers for photonic applications.

The so-called orientational enhancement effect[7] is responsible for the high efficiency of low T_g polymers in plasticized PVK-based materials. To fully characterize the different contributions to the total photorefractive refractive index modulation amplitude, we have developed a new frequency-dependent ellipsometric technique[8] that enables the determination of the orientational contribution, the linear electro-optic contribution, and the Kerr contribution. This technique was applied to DMNPAA:PVK:ECZ:TNF samples and the microscopic parameters of DMNPAA could be deduced.[8] A good theoretical fit to the four-wave mixing data calculated with these parameters could be obtained simultaneously for s- and p-polarized read-out.

New polymers with extended sensitivity in the infra-red are now developed in our group. Extended sensitivity in the infra-red improves the wavelength compatibility of these polymers with semiconductor laser diodes for applications and it also enables the use of chromophores with higher nonlinearity. Thus, new polymers with even higher efficiency and/or comparable efficiency at lower applied field can be developed. One way of extending the sensitivity is to dope the material with new sensitizers. We have done four-wave mixing experiments at 830 nm by using the charge transfer complex that is being formed between carbazole and TNFDM. We also propose another approach where the sensitizer and the photoconducting functions are implemented in two different layers. Such bi-layer devices offer a lot of flexibility since the solubility and compatibility of the sensitizer with the other functional dopants are no longer a hurdle. We have made examples of bi-layer devices where a thin layer of TiO-Phthalocyanine (TiO-Pc) is used as a sensitizer and where the photogenerated carrier are being injected from the TiO-Pc layer into a DMNPAA:PVK:ECZ layer. Diffraction efficiencies of 70% could be measured in such devices.

Due to the high refractive index modulation amplitudes that can be achieved in these highly efficient photorefractive polymers (Δn = 0.007), the recording of thick phase grating in these materials can also lead to non-Bragg diffraction orders.[9] This effect is different from higher diffraction orders observed in the Raman-Nath diffraction on thin gratings. For instance, diffraction is not obtained for beams incident at arbitrary angles like in thin gratings and the higher

diffraction orders can not be described by Bessel functions. Such non-Bragg diffraction orders have been observed and their properties including phase-conjugation and phase-doubling are demonstrated.

Finally, to illustrate the technological potential of photorefractive polymers for optical processing applications we have demonstrated an all-optical, all-polymeric correlator for security applications. In this correlator, a highly efficient PVK-based polymer is used as the nonlinear medium for security verification of documents such as credit cards optically encoded with pseudo-randomly generated phase masks. The use of a low cost photorefractive polymer as active medium keeps the overall manufacturing cost of the device sufficiently low to make it technologically viable.

Acknowledgments: This work was supported by ONR through the Center for Advanced Multifunctional Nonlinear Optical Polymers and Molecular Assemblies (CAMP), by NSF, by AFOSR, and by an NSF-CNRS collaboration program. We acknowledge O. Savina for her help during sample preparation, and collaboration with Drs. K. Meerholz, N. V. Kukhtarev, B. Javidi, and CAMP members.

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