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Third Quarterly Technical Report

Analysis and Evaluation of Technical Data on the Photochromic and Non-Linear Optical Properties of Materials

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George Mason University

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Background

The overall goal of this relatively small contractural effort is to provide technical assistance to Dr. Frank Patten (DARPA) in evaluating data on materials, especially polymers, that may be useful in the development of optical limiters for the protection of eyes and electro-optic sensors from exposure to damaging levels of laser radiation. A principle task is to assist in the development of a predictative capability in assessing the viability of various protective approaches and to determine the theoretical limitations which may exist in the use of organic materials as optical switches and limiters.

Progress to Date

A search of the literature has been essentially completed in an attempt to gather into one table the magnitude of the non-linear optical properties of various organic materials as a function of molecular structure. The first quarterly technical report (March 1989) included a partial list of reference being reviewed. The second quarterly report included a lengthy table of organic systems and their reported NLO properties. Since that date, the literature search has been completed and the findings have been formally reported as a Naval Research Labortory report (NRL Memorandum Report #6482). The Principal Investigator is also employed at the Naval Research Laboratory as an intermittent employee, GM 15. Activities associated with this project have been coordinated with NRL in an attempt to reduce duplication of effort and to stay abreast of technological developments and realistic problems and needs of the military community.

A co-worker (Dr. Robert Honeychuck) of the Principal Investigator, as part of this contractural effort, attended the Army conference on "Non-Linear Optical Polymers for Soldier Survivability" held in Natick, MA. Little new information, not previously present in other formats and forums, was presented. Of specific interest were presentations on macrocyelic structures (e.g. phthalocyanine) and work on phthalocyanine structures as the backbone, but not conjugated with each other. Several presentations on polydiacetylene were of interest. A general feeling is that, in order to achieve the NLO requirements of the eye/sensor hardening program, at least two and probably several orders of magnitude increased over the current chi-3's reported for existing materials is required. Ideally, but most difficult to achieve, this should be an increase in NLO response in a broad and non-resonant region of the spectrum.

Two generic molecular structures which offer the greatest near term promise for high chi-3 systems are the phthalocyanine structures and ladder polymers, especially those containing heteronuclear atoms (S or N) in the aromatic ring. In addition, both of these molecular systems tend to be thermally stable, enabling them to survive relatively large doses of absorbed laser radiation. Phthalocyanine chromphores are genrally deeply colored and thus strong light absorbers. They may be limited to use as resonant chi-3 materials. Since their absorption bands are generally narrow, stacking of thin layers of differently substituted phthalocyanine based structures, each with response in a different wavelength region, may lead to a system with a broad wavelength response, but with sufficient transparency between absorption bands.

Mirror/Optical Fuse Concept

Analysis and discussion of an ablative mirror/optical fuse system located at the focus of an optical device used for eye/sensor hardening has been undertaken as a tangential effort under this project. Although it may not be appropriate under the most narrow definition of the scope of this project, it is viewed by the Principal Investigator as a worthwhile and appropriate effort. A first approximation concept and feasibility study is included as an attachment to this quarterly report. Within this appended report, several approaches to lowering the fuse failure threshold energy are suggested, including use of a free standing reflective film and a thermochemically assisted fuse failure enhancement concept.

Technical Advisory Committee

The Principal Investigator has been appointed by Dr. Frank Patten (DARPA) to an ad hoc Technical Advisory Committee to assess the feasibility of a variety of materials and systems associated with the eye/sensor hardening program. This committee met during this quarter and began work on several assigned tasks. Progress will be reported in the next quarterly report.

Attachment: "Eye/Sensor Protection by an Optical Fuse Mirror at a Focal Plane: A Feasibility Assessment"