Project 86797

Development and Applications of Photosensitive Device Systems to Studies of Biological and Organic Materials

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RESULTS TO DATE: [Numbers in brackets refer to publications in the publication list]

1. R&D and application testing are proceeding on Pixel Array Detectors (PADs) for time-resolved and crystallographic applications at synchrotron radiation (SR) sources [1, 2, 4, 23, 24]. In conjunction with an NIH-funded SBIR grant, a novel mixed-mode analog/digital pixel design is being developed. Reports and publications on recent developments in the hybrid detector will be presented at the IEEE Nuclear Science Symposium in Rome in October, 2004 [21-23]. We've been invited to help prepare a special issue of Journal of Synchrotron Radiation on x-ray detectors; additionally, we will contribute an article on fast time-resolved PADs [24]. Application of a PAD developed under a DOE Facilities Initiative Grant, in collaboration with Dr. Jin Wang's group at the Advanced Photon Source, is being intensively used for microsecond time-resolved x-ray imaging of fuel injectors [3, 15]. This detector is the primary data acquisition device used by the Wang collaboration for work which was awarded the 2002 DOE Combustion and Emission Control R&D award.

2. A novel technique has been developed to use inelastic x-ray scattering to probe ultra-fast time resolved electronic rearrangements in matter. The long term goal is to use the method to help understand photo-excitation events in proteins and chromophores. The method was used to image the time-sequence of plasmon density disturbances in water upon photoelectron ejection in 41 attosecond steps, which is an order of magnitude faster than any comparable prior structural measurement [9]. This work attracted a lot of attention and was featured as a break-through in AIP Physics Focus [http://focus.aps.org/story/v13/st25] and on the lead page of Chemical & Engineering News [http://pubs.acs.org/cen/news/8225/8225notw1.html]

3. An important part of our research program is the testing and application of the technology developed under DOE. Recent examples include protein ion-channel studies [18], NMR methods of the determination of chemical structure [10], and CCD detectors applied to investigations of polymeric and composite materials [2, 5, 7-8, 11-12, 16-17, 20].

4. Considerable work is being done on the development of high-pressure crystallography [13] as a means of understanding protein functioning. An apparatus has been developed to freeze proteins under pressure and analytical methods have been developed to solve for collective structural changes in crystals frozen under pressure but examined at ambient temperature. It is believed that this work will open a huge, fertile area for the study of biomolecules. We have discovered that protein crystals normally very difficult to cryo-freeze for crystallography may be readily frozen under high pressure, a result that may have considerable practical significance for structural biology. A paper on the method is being prepared. Finally, a small-angle x-ray scattering cell to examine protein unfolding under pressure has been built and tested at a synchrotron source. This cell overcomes corrosion and loading problems endemic to earlier cell designs. The first application will be to the study of the aggregation of proteins implicated in Alzheimers-like diseases.

5. Although it is only peripherally supported by this grant, work is proceeding on the development of a new type of synchrotron radiation source, called an Energy Recovery Linac, which has superior characteristics to storage rings [1, 4, 6, 19]. When developed, this source could have enormous effects on the entire synchrotron radiation community and open many new possibilities in biological imaging.

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