

REPORT DOCUMENTATION PAGE			Form Approved OMB NO. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comment regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 9/12/96	3. REPORT TYPE AND DATES COVERED Final Progress Report		
4. TITLE AND SUBTITLE Ultrafast Broadband Photodetectors for High-T _c Superconductive Optoelectronics			5. FUNDING NUMBERS DAA103-91-G-0318	
6. AUTHOR(S) P. M. FAUCHET				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Rochester EE Department Computer Studies Bldg. Rochester, NY 14627			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211			10. SPONSORING / MONITORING AGENCY REPORT NUMBER ARO 29184.2 - PH	
11. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.				
13. ABSTRACT (Maximum 200 words) The femtosecond optical response of YBCO films has been determined by pump-probe experiments after excitation with ultrashort optical pulses generated by a copper vapor amplified colliding pulse modelocked dye laser. From the results we have obtained as a function of pump intensity, probe wavelength and sample temperature, we find that contrary to the usually accepted interpretation, the position of the Fermi level is not at 2 eV above the copper d-band in oxygen-rich samples (at room temperature) and that the low-temperature optical response is not consistent with the destruction of superconductivity through the destruction of a large density of Cooper pairs via an avalanche process, followed by the restoration of superconductivity on a time scale of several picoseconds. In addition, the laser writing technique has been developed and refined to fabricate simple microbridges in initially oxygen-rich YBCO films.				
DTIC QUALITY INSPECTED 1				
14. SUBJECT TERMS high-temperature, superconductors, optoelectronics, femtosecond phenomena			15. NUMBER OF PAGES	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OR REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

**Ultrafast Broadband Photodetectors for
High- T_c Superconductive Optoelectronics**

FINAL PROGRESS REPORT

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September 9, 1996

U.S. ARMY RESEARCH OFFICE

DAAL03-91-G-0318

UNIVERSITY OF ROCHESTER

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DESIGNATED BY OTHER DOCUMENTATION.

FINAL REPORT

1. ARO PROPOSAL NUMBER: 29184-PH
2. PERIOD COVERED BY AWARD: September 1, 1991 -August 31, 1992
3. TITLE OF PROPOSAL: Ultrafast Broadband Photodetectors for High-Tc Superconductive Optoelectronics
4. CONTRACT OR GRANT NUMBER: DAAL03-91-G-0318
5. NAME OF INSTITUTION: University of Rochester
6. AUTHOR OF REPORT: Professor Philippe M. Fauchet
7. LIST OF MANUSCRIPTS PUBLISHED UNDER ARO SPONSORSHIP DURING THIS REPORTING PERIOD, INCLUDING JOURNAL REFERENCES:
 1. Prospects for high-Tc superconducting optoelectronics, in AIP Conference Proceedings 251, edited by Y.H. Kao et al, American Institute of Physics, New York, 1992, pp 659-670.
8. SCIENTIFIC PERSONEL SUPPORTED BY THIS PROJECT AND DEGREES AWARDED DURING THIS REPORTING PERIOD:

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Professor Roman Sobolewski
Dr. LiXing Zheng
9. REPORT OF INVENTIONS:

None

SUMMARY OF RESEARCH FINDINGS

Our goal is to demonstrate a high-speed, broadband photodetector made of a YBCO thin film integrated circuit. To achieve the highest speed possible, the first step is to identify the mechanisms that allow a picosecond or femtosecond optoelectronic response. We have performed a series of experiments on YBCO films using femtosecond optical pulses generated by a colliding pulse modelocked dye laser tuned at 620 nm (2 eV). Groups at MIT, the University of Utah, the University of Michigan, GM and Bellcore have published results obtained with the same laser system in the past two years. The set-up in their experiments as well as in our experiments is a typical time-resolved pump-probe arrangement. It is fair to say that not only did similar experiments sometimes produce conflicting results, but also that conflicting interpretations have been proposed to explain the same results. We have gone beyond these simple experiments, by amplifying our femtosecond laser pulses using a copper vapor laser. These amplified pulses are then focussed on a ethylene glycol jet, where they generate a white light continuum. As a result, we can select probe pulses that are synchronized with the pump pulses but in addition can be tuned from the near infrared to the green parts of the optical spectrum. This entire system allows us to 1) study the optical response at 2 eV over a very wide range of excitation power and 2) study the optical response at other wavelengths after production of a white light continuum. In our results, the optical response following light absorption at 2 eV is independent of the wavelength at which the observation is made. This "color-blind" response contradicts the most popular explanation proposed for 2 eV experiments performed at room temperature, which postulates that the Fermi level is located at 2 eV above the copper d-band. Our other experiments also contradict a promising interpretation of low-temperature experiments, which invokes destruction of superconductivity on a subpicosecond time scale by destruction of enough Cooper pairs through an avalanche process, followed by restoration of superconductivity on a several picosecond time scale. We find that destruction of superconductivity requires a rather intense beam, available only with our amplified pulses. Under these conditions, the recovery of the superconductivity appears to be significantly slower in our samples, most likely because of a bolometric effect.

Additional femtosecond measurements should then be performed on samples with varying degrees of oxygen doping, including semiconducting samples. In addition, the range of wavelengths over which both excitation and probing are performed could be extended. This will, in the future, allow us to identify the nature of the optical response of YBCO films. Furthermore, optoelectronic measurements should be performed on YBCO bridges prepared as described below. This will allow us, in the future, to measure and optimize the electrical response of our photodetector structures following optical excitation with an ultrashort optical pulse.

We have built a laser-writing station, which includes an Ar-ion cw laser (wavelength of 514 nm), focusing microscope, and computer controlled stage with a small gas chamber to control the ambient atmosphere during the process. A number of test structures (microbridges of various lengths and widths) have been fabricated by laser-writing in initially oxygen-rich (superconducting) Y-Ba-Cu-O (YBCO) films and measured. The superconducting YBCO films were deposited *in-situ* by rf magnetron sputtering on MgO, SrTiO₃, and LaAlO₃ single crystals and patterned using the laser ablation method. The laser-written microbridges could be made with lines below 10 μm , demonstrating that our optical system is well optimized.

The electrical properties of the microbridge are excellent. Depending on the laser treatment, the properties of the YBCO film can be changed from superconducting to semiconducting. The method is quite reproducible and we were able to obtain a sharp interface between the superconducting and non-superconducting (laser-written) regions. Future work should investigate the possibility of fabricating entire device structures. To reach that goal, we are in the process of

implementing full, two-dimensional (x- and y-axis) writing capabilities in our system and we are continuing to optimize the writing procedure in oxygen-rich YBCO films. In future research, we will develop "recipes" for reproducible writing of superconducting (oxygen-rich) lines in initially semiconducting (oxygen-depleted) films .