

Laser Programmed Conducting Polymers

Final Report

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10 December, 1995

U.S. Army Research Office

29373-PH

19960212 070

Rice University

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 12/10/95	3. REPORT TYPE AND DATES COVERED Final 13 May 92 - 12 May 95	
4. TITLE AND SUBTITLE Laser Programmed Conducting Polymers			5. FUNDING NUMBERS ARO MIPR 158-94	
6. AUTHOR(S) Prof. Roland Sauerbrey			8. PERFORMING ORGANIZATION REPORT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Rice University Department of Electrical and Computer Engineering P.O.Box 1892 Houston, Texas 77251			10. SPONSORING/MONITORING AGENCY REPORT NUMBER ARO 29373.10-PH	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211			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.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The metal insulator transition observed in excimer laser irradiated polyimide was characterized in terms of percolation theory. The critical exponent for electrical conductivity was measured to be 2.00 ± 0.05 in exact agreement with the percolation theory predictions. Carbon fiber formation under an applied electric field was also observed and investigated. The observation of nonlinear I-V characteristics and the relation of this observation to the percolation theory is an object of continuing investigations.				
14. SUBJECT TERMS laser induced conductivity in polyimide percolation excimer lasers			15. NUMBER OF PAGES 5	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

A. Problem Studied

Laser induced electrical conductivity in polyimide was studied near the critical point. As the system has been described by percolation theory, characterization in terms of percolation threshold and critical exponents was sought.

B. Results

An *in situ* measurement technique was developed which allowed us to measure conduction during laser processing. A typical result is shown in Fig.1, where electrical conductivity is shown as a function of the number of laser pulses and the volume fraction of transformed material. The curve fits shown are for a power law of the form:

$$\sigma = (p - p_c)^t \quad (1)$$

which is from the percolation theory [1] where p is the conducting volume fraction of the conductor insulator mixture and p_c is the critical volume fraction where the conductivity first appeared. Theory predicts that $t \sim 1.9 \pm 0.1$ [1] and the exponent found here was 2.00 ± 0.05 further confirming the percolation description of the phenomenon and perhaps making an experimentally precise confirmation of the percolation theory itself.

Also noted in the same study was the tendency for carbon fibers to form on the surface of samples when the applied voltage was high. These fibers would form in the first hundred laser pulses and had substantial electrical conductivities.

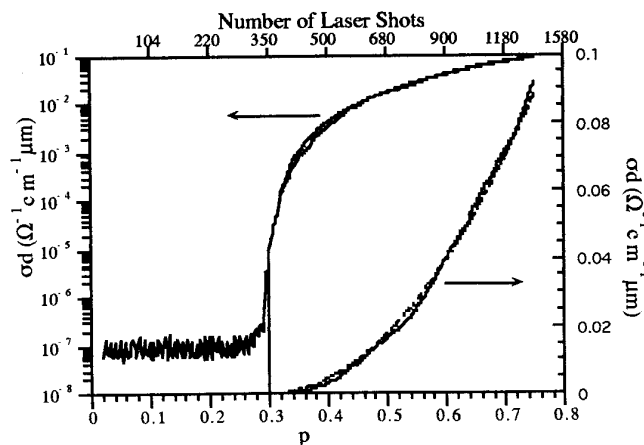


Fig.1. Conductivity as a function of the conducting volume fraction p and number of laser pulses. Curve fits correspond to power laws in percolation theory and agree exactly with theoretical predictions

Also of interest was the observation of nonlinear I-V characteristics for samples near the threshold. The relation of this observation to the percolation theory is a subject of continuing interest.

Publications

Z. Ball, H.M. Phillips, D.L. Callahan, and R. Sauerbrey, "Percolative metal insulator transition in excimer laser irradiated polyimide", *Physical Review Letters* **73**, 2099 (1994)

Z. Ball and R. Sauerbrey, "Lowering of the conduction threshold through carbon fiber formation in KrF excimer laser irradiated polyimide", *Applied Physics Letters* **65**, 391 (1994).

Personnel

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[1] J.P. Clerc, G. Giraud, J.M. Laugier, and J.M. Luck, *Adv. Phys.* **39**, 191 (1990)

List of Figures

Figure 1 Conductivity of laser irradiated polyimide as a function of laser pulses.