AD-A141 674 SYNTHESIS AND EVALUATION OF IMPROVED ELECTRON-BEAM AND X-RAY LITHOGRAPHIC RESIST POLYMERS(U) ALABAMA UNIV UNIVERSITY C U PITTMAN MAY 84 ARO-16201.9-CH 1/1

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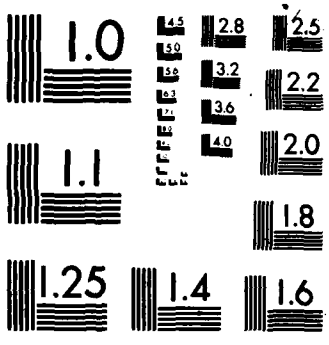

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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20. ABSTRACT CONTINUED:

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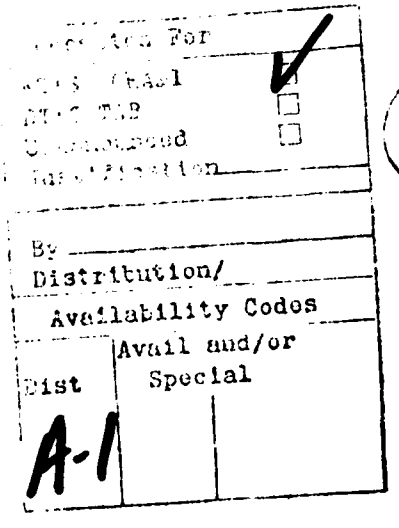

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FINAL REPORT

Army Research Office

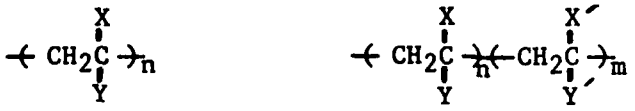
Contract No. DAAG-29-79-C-0128

SYNTHESIS AND EVALUATION OF IMPROVED ELECTRON-BEAM AND X-RAY LITHOGRAPHIC RESIST POLYMERS

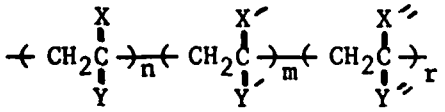
Charles U. Pittman, Jr.
Principal Investigator

INTRODUCTION

It was the goal of this research to investigate the relationship between the chemical structure of polymers and the properties which would result in a new generation of lithographic resists for electron-beam and X-ray lithography. Thus, the synthesis of a variety of vinyl homopolymers, copolymers and terpolymers was undertaken where quaternary centers were present along the polymer backbone. These quaternary centers were the sight of chain scissions that occurred on irradiation (γ-ray, X-ray and electron-beam exposure) thereby leading to positive resist behavior. In addition to varying the chemical structures at the quaternary center (i.e. groups X and Y below) and making the novel polymers, we also undertook to purify and characterize the polymers, to fractionate the polymers into specific molecular weight range fractions, to determine the fundamental radiation sensitivity of the polymers (i.e. establish their G_s and G_x values), and to characterize these polymers as lithographic resists by evaluating their sensitivity and, when possible, their dry etch characteristics (i.e. plasma etch resistance).



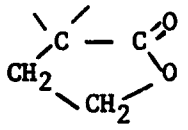
homopolymer copolymer

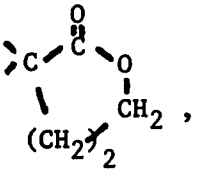


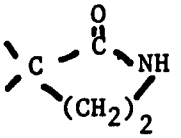
terpolymer

During the course of the contract we prepared a very large number of homopolymers, copolymers and terpolymers where X and Y were chemical functions

such as: -CN, $-COOCH_3$, -Cl, -Br, -F, $-CF_3$, $-COOCH_2CCl_3$, $-COOCH_2CN$, $-COOCH(CF_3)_2$, $-COOCH_2CF_3$







and CH_3.

These syntheses included the preparation of monomers never yet prepared. After preparing the polymers, their radiation degradation behavior was studies using ^{60}Co γ-irradiation. Dose versus molecular weight measurements ($\bar{M}_n$, $\bar{M}_w$) were used to determine G_s and G_x. The G_s and G_x data was elucidated as a function of chemical structure (i.e. X and Y) and for copolymer composition (i.e. as a function of the monomer-1 and monomer-2 composition of the copolymer). Copolymers and terpolymer solubilities were studied because some homopolymers, particularly those containing -CN groups, were only soluble in nitrile containing solvents (or they were insoluble). The electron-beam sensitivities of several systems were established by determining the electron-beam doses which would permit wet development of the irradiated areas down to a SiO_2-coated Si wafer surface. Finally, dry processing characteristics were evaluated in some cases. CF_4/O_2 plasmas were employed in order to establish the absolute etch rates and etch rates relative to SiO_2 and relative to poly(methyl methacrylate).

Work supported on this contract has resulted in the patent and the publications listed below. It should be noticed that a significant amount of the work reported below was jointly performed with the U. S. Army Electronics Technology and Devices Laboratory, Ft. Monmouth, New Jersey.

Patent

John N. Helbert and Charles U. Pittman, Jr. U. S. Patent 4,304,840 December 8, 1981 "Method of Delineating a Desired Integrated Circuit Pattern Upon a Circuit Substrate"

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Students and Other Researchers Receiving Support On
DAAG-29-79-C0128

Principal Investigator

C. U. Pittman, Jr.
100% 1.5 months
15% .5 months
46% 1.5 months

Research Assistants

J. J. Yang
100% 3.23 months

E. Wallace, Jr.
50% 9.0 months
50% 9.5 months
43% 3.0 months
50% 4.5 months

Post Docs

P. J. Wang
100% 12.0 months
100% 11.93 months

T. V. Jayaraman
100% 12.0 months
100% 12.0 months

Graduate Assistant

S. S. Jada
28% 9.0 months
17% 9.0 months

Undergraduate Assistants

K. J. Sluder
66 hours

M. F. Desmond
101 hours

B. K. Tielking
552 hours

Technician

R. H. Glaser
50% 3.0 months

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