AD-A190 535 LASER PHOTODEPOSITION AND ETCHING STUDY(U) RENSSELAER 1/1
POLYTECHNIC INST TROY NY DEPT OF MATHEMATICAL SCIENCES
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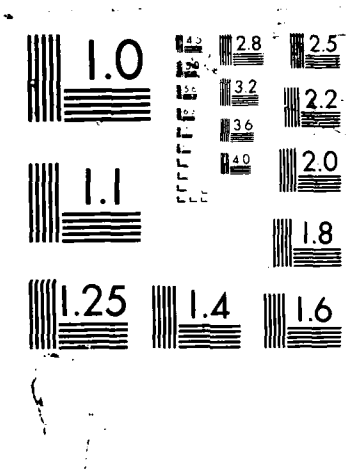
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SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED

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REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION	1b RESTRICTIVE MARKINGS DTIC FILE COPY
2a 2b **AD-A190 535**	3 DISTRIBUTION AVAILABILITY OF REPORT Approved for public release distribution unlimited.
4.	5 MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR-TR- 87-1765

6a. NAME OF PERFORMING ORGANIZATION Rensselaer Polytechnic	6b OFFICE SYMBOL (*If applicable*)	7a NAME OF MONITORING ORGANIZATION AFOSR/NM
6c. ADDRESS (*City, State, and ZIP Code*) Troy, NY		7b ADDRESS (*City, State, and ZIP Code*) AFOSR/NM Bldg 410 Bolling AFB DC 20332-6448
8a. NAME OF FUNDING/SPONSORING ORGANIZATION AFOSR	8b OFFICE SYMBOL (*If applicable*) NM	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER AFOSR-86-0179
8c. ADDRESS (*City, State, and ZIP Code*) AFOSR/NM Bldg 410 Bolling AFB DC 20332-6448		10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO: 61102F; PROJECT NO: 2304; TASK NO: A9; WORK UNIT ACCESSION NO:

11 TITLE (*Include Security Classification*)

Laser Photodeposition and Etching Study

12 PERSONAL AUTHOR(S)

A. Novick-Cohen

13a TYPE OF REPORT	13b. TIME COVERED	14 DATE OF REPORT (*Year, Month, Day*)	15 PAGE COUNT
Final	FROM 1 Jul 86 TO 30 Jun 87	June 1987	3

16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (*Continue on reverse if necessary and identify by block number*)
FIELD	GROUP	SUB-GROUP	

19 ABSTRACT (*Continue on reverse if necessary and identify by block number*)

The important result reported is that under a distinguished limit procedure an alternative to the K-S Equation is obtained when modelling the evolution of solidification fronts. Three papers are being prepared for publication.

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20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION
22a. NAME OF RESPONSIBLE INDIVIDUAL Dr. Arie Nachman	22b TELEPHONE (*Include Area Code*) (202) 767-5027
	22c OFFICE SYMBOL NM

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted
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UNCLASSIFIED

Final

~~PROGRESS &~~ FORECAST REPORT

Grant No. AFOSR-86-0179
January 1987

A. Novick-Cohen
Department of Mathematical Sciences
Rensselaer Polytechnic Institute
Troy, New York

Present address:

Department of Mathematics
Wells Hall
Michigan State University
East Lansing, Michigan 48824

Abstract:

1) **Solidification Fronts:** Asymptotic equations are derived to model the evolution of the solid-liquid interface which occurs in the directional solidification of binary alloys. In the limit where $GD/VC_o(g + f_c)$ is small, the Kuramoto-Sivashinsky equation is obtained. Here G is the imposed temperature gradient, D is the diffusion coefficient of the impurity, V is the imposed transport velocity, g is equal to minus the slope of the liquidus line, C_o is the impurity concentration at the liquid side of a planar interface, and f_c is a coefficient reflecting deviations from local thermal equilibrium. The cusping and intermittancy contained in the Kuramoto-Sivashinsky equation may help to explain the creation of defect points and the onset of loss of coherency. In the limit where the segregation coefficient is small, an alternative to the Sivashinsky equation is obtained. In the new equation a quadratic nonlinearity is replaced by an exponential term. The new equation is believed to more accurately describe the solidification profile.

2) **Viscous Phase Transition:** Two equations are derived and analyzed which model the dynamics of viscous first order phase transitions. Inclusion of both viscous and gradient energy terms yields the viscous Cahn-Hilliard equation,

$$c_t = \Delta(f(c) + \nu c_t - K\Delta c) \quad . \qquad (1)$$

Here $c(x,t)$ is a concentration, $f(c)$ is an intrinsic chemical potential which should be nonmonotone in systems exhibiting phase separation and ν and K are respectively coefficients of viscosity and gradient energy. In the limit $K \to 0$, equation (1) reduces to a viscous diffusion equation

$$c_t = \Delta(f(c) + \nu c_t) \qquad (2)$$

and in the limit $\nu \to 0$, (1) reduces to the well-known Cahn-Hilliard equation.

$$c_t = \nu(f(c) - K\Delta c)$$

Equations (1) - (3) can be viewed as viscous and/or gradient energy regularizations of the backwards-forwards heat equation. A comparison theorem shows that early stages in the evolution of (1) follow closely the behavior of (2) for small K. The asymptotic behavior of (1) and (2) are contrasted. Equation (2) admits the possibility of discontinuous equilibria. Equation (1) initially develops transients which probably evolve and decay in much the same way as is believed to occur in the Cahn-Hilliard equation.

Table of Contents

Report Documentation

Report

Appendix I

Appendix II

Appendix III

(ii) Report:

Solidification Fronts:

If deviations from local thermal equilibrium are taken into account, then it is possible to obtain a Kuramoto-Sivashinsky equation as a model equation for the solid-liquid interface present in the directional solidification of a dilute binary alloy. The derivation is given in a revised version of a paper which has been accepted for publication in Physica D (Appendix I). The AFOSR acknowledgement will be added in proof. In the small distribution coefficient limit, a similar derivation gives rise to a Sivashinsky equation. (Here local thermal equilibrium is assumed.) In a forthcoming paper, an alternative derivation gives rise to a similar equation in which the quadratic nonlinearity is replaced by an exponential term. This new equation is now being studied. A rough abstract of this forthcoming paper is included here (Appendix II).

Viscous Phase Transitions:

Appendix III contains a contribution to the Heriot-Watt Symposium on Non-classical Continuum Mechanics. A more detailed account of our results will appear in

[1] Novick-Cohen, A. and Pego, R.L., Viscosity and the dynamics of phase decomposition, in preparation.

[2] Novick-Cohen, A. and Pego, R.L., On the viscous Cahn-Hilliard equation, in preparation.

[3] Novick-Cohen, A. and Pego, R.L., Analysis of a viscous diffusion equation, in preparation.

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