AD-A178 458 SUBMICRON CHARACTERIZATION OF THE ATOMIC AND ELECTRONIC STRUCTURE OF DEFE..(U) ARIZONA STATE UNIV TEMPE DEPT OF PHYSICS J C SPENCE 03 FEB 87 ARO-20088.14-MS 1/1

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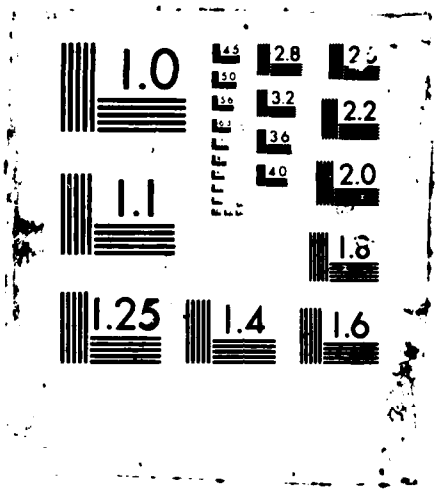
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Submicron Characterization of the Atomic & Electronic Structure of Defects in Semiconductors

Final Report

J.C.H. Spence

February 3, 1987

U.S. Army Research Office

DAAG29-83-K-0087

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARO 20088.14-MS	2. GOVT ACCESSION NO. AD-A178 458 N/A	3. RECIPIENT'S CATALOG NUMBER N/A
4. TITLE (and Subtitle) Submicron Characterization of the Atomic & Electronic Structure of Defects in Semiconductors		5. TYPE OF REPORT & PERIOD COVERED 6/1/83-9/30/86 Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Prof. J.C.H. Spence		8. CONTRACT OR GRANT NUMBER(s) DAAG29-83-K-0087
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Physics Arizona State University, Tempe, AZ 85287		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Research Office Post Office Box 12211 Research Triangle Park, NC 27709		12. REPORT DATE February 3, 1987 13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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18. SUPPLEMENTARY NOTES

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Infra-red Cathodoluminescence
Electron Energy Loss Spectroscopy
Electron Microdiffraction
Electron Channeling
Coherent Bremsstrahlung

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

New submicron defect characterisation techniques have been developed, including energy loss spectroscopy and cathodoluminescence in TEM. This has allowed the first observations of infra-red emission from groups of well characterised dislocations in silicon, and the spatial mapping of luminescence in GaAs. The basic theory and corresponding experiments have been developed for coherent bremsstrahlung and electron energy loss spectroscopy (E.L.S.) (in Be_2C in particular. ELS allows chemical and structural information to be obtained from subnanometer regions of material.

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1. Statement of problem studied

This research is aimed at developing new techniques for the characterisation of sub-micron defects in semiconductors by electron beam methods.

2. Summary of main results

New submicron defect characterisation techniques have been developed, including energy loss spectroscopy and cathodoluminescence in TEM. This has allowed the first observations of infra red emission from groups of well characterised dislocations in silicon, and the spatial mapping of luminescence in GaAs. The basic theory and corresponding experiments have been developed for coherent bremsstrahlung and electron energy loss spectroscopy (E.L.S.) (in Be_2C in particular). ELS allows chemical and structural information to be obtained from subnanometer regions of material. In addition, a new timing coincidence method for the spatial mapping of carrier lifetimes in semiconductors has been developed, in which the time between electron beam excitation (measured by electron energy loss spectroscpy) and photon emission (measured by cathodoluminescence) is measured (see references). The effects of local crystallographic environment on the near edge "absorption" fine structure of the K shell edges in Be_2C have been measured by E.L.S. and analysed in detail, using multiple scattering "XANES" programs. New emission lines have been observed and studied in undoped LEC GaAs, and in Zn doped GaAs.

More details of the individual projects are given below.

1. We are the first to observe the luminescence spectra of individual dislocations in semiconductors of known character. I consider the paper on dislocations in diamond to be the major return on our effort in constructing the TEM cathodoluminescence apparatus. Using the polarization properties of the luminescence from individual dislocations we were able to develop a theoretical model for their electronic structure.

2. We are the first to observe Coherent Bremsstrahlung (C.B.) effects in electron microscopy, and in axial orientations generally. Since the intensity of this monochromatic X-ray radiation is related to crystal structure factors, we plan to study its use for the analysis of defects in crystals. We have observed strong C.B. effects in many materials, and given a unified Bloch-wave theory of both C.B. and Channelling Radiation.

13. In the X-ray microanalysis of crystalline samples the bremsstrahlung background is concentrated into peaks called coherent bremsstrahlung. By choosing an accelerating voltage such that these peaks avoid characteristic emission lines, the sensitivity of microanalysis may be increased.

14. Carrier lifetimes in semiconductors may be spatially mapped by using coincidence counting between the CL signal and the electron energy loss signal in a TEM.

15. A fourier transform spectrometer has been fitted to a CL apparatus on a TEM instrument in order to obtain infra-red emision spectra from submicron areas in correlation with TEM images. (see refs. for results).

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