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SEMI-ANNUAL REPORT/PROGRESS REPORT

for

1 February 1985 through 31 July 1985

for

Contract N00014-(84K-0423)

Task No. NR (243-049)

"Diffusion and Defect Characterization Studies of
Mercury Cadmium Telluride"

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Sponsored by Defense Advanced Research Projects Agency (DoD)
Defense Sciences Office
ARPA Order #5019
Issued by Office of Naval Research
SFRNO. N00014-84K-0423

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Liquid + Solid

I. Progress During the Reporting Period

During the last six months, progress has been made on the two major areas of this program: Diffusion studies in mercury cadmium telluride (MCT), and growth studies. In the former area, self diffusion measurements have been made, with emphasis on the comparison of experiments using a pure Hg reservoir and experiments using a (L+S) reservoir. In the growth studies, major emphasis has been on the analysis and theory of the isothermal vapor phase epitaxial growth process (IVPE). More details of these activities are given below.

A. Diffusion Studies

Mercury tracer diffusion in $\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$ is studied by two kinds of reservoirs, (Hg(l) and the liquid + solid (L/S) reservoir described in the previous progress report), and the appropriate annealing time for specific temperatures and pressures were determined to elucidate the branches of tracer profiles. For both types of reservoirs, three branches were observed; at 500°C the branch corresponding to the fastest diffusion is always flat and the corresponding D value cannot be determined. The other two branches are the same for both type of reservoirs. Both Hg-rich and Te-rich L/S thermodynamically well-defined reservoirs were used to compare with the results using a pure Hg reservoir. Metallographic examination shows the multiplication of dislocations after Hg diffusion, which is consistent with the observations reported by H.F. Schaacke and J.H. Tregilgas - J. Electronic Materials 12, No. 6 pg. 932 (1983). With Te precipitates present before

and after annealing, there is one more condensed phase besides MCT(s), thus decreasing the degrees of freedom by one. This may explain the consistency in the results using the two kinds of reservoirs. The vapor pressure dependence of Hg^{203} diffusion coefficient has been studied; the slope of $\ln(D)$ vs. $\ln(P_{\text{Hg}})$ requires the accurate measurement of temperature. Accurate calibration of the furnace is in progress. Preliminary Cd and Te tracer diffusion studies are in progress. The initial results show that there are three branches in the tracer profiles for both Cd and Te. Autoradiography techniques are being developed to investigate the sources of these complicated diffusion branches.

B. Growth Studies

Work has been performed on VPE using a novel source material consisting of ~90% MCT of a desired X value and ~10% LPE melt corresponding to that X value and growth temperature. This type of source fixes the chemical potential over the source and enables us to fix the surface composition of the growing layer under certain conditions. Using these sources, a series of experiments were performed in which only one growth parameter at a time was varied. Using these results and available thermodynamic data we developed a model for this process. Growth is driven by a lowering in the total free energy of the total system. Kinetically, it appears that growth is the result of two interconnected processes: transport of Te_2 from the source to the substrate where it

reacts with Hg and Cd within the growing layer. Using this growth technique with a slightly modified geometry we have been able to grow a continuous series of different compositions on the same substrate. Material of this type has been used to study the hardness of MCT and ion implantation damage. The results of the work on hardness generally support the results of Cole et al.

Using the results of our previous work in VPE we have devised a new method of determining interdiffusion coefficients. The method requires knowledge of the surface composition, layer thickness, and composition at the composition of interest. This method offers a number of advantages in controlling the system, the sample orientation, and the interface structure, since the samples are oriented and there is no discontinuity throughout the layer. Work is still in progress, but experiments performed between 450-700°C indicate that the interdiffusion coefficient follows the relation:

$$\bar{D}_x = 1380 e^{-7.87e - \frac{2.0}{kT}}.$$

II. Planned Activities for the Next Reporting Period

The work planned for the future will emphasize the following topics: continuation of the tracer diffusion studies and interdiffusion studies, with specific emphasis on the dependence upon component pressures; evaluation of the electronic properties, impurities, and defects in isothermal vapor phase epitaxial MCT (IVPE); exploration of a new method

of epitaxial growth by isothermal liquid phase epitaxy from Hg melts; and evaluation of a new method for growth of wafers of MCT using the IVPE method with a post growth homogenization anneal.

III. There are no changes in the key personnel in the reporting period.

IV. D. A. Stevenson and J. G. Fleming made presentations: at the "DARPA" Focal Plane Array Materials and Processing Review" (Washington, D.C., 2-4 April, 1985); at the Materials Science Affiliates Meeting at Stanford, May 30, 1985; at the "Eighth Conference on Crystal Growth, AACG/West (at Fallen Leaf Lake, CA, 4-7 June 1985; and at the Santa Barbara Research Center (Goleta, CA, 1 July 1985).

V. In response to written correspondence and telephone conversations regarding the projected time and financial resources needed to complete our work, a renewal proposal request will be submitted in September.



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