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October 8, 1997

Dr. Yoon Soo Park
Program Officer
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217-5660

Dear Dr. Park:

This is the first report on Contract N00014-97-C-0367, "Hexagonal II-VI Structures by Substrate Bandgap Engineering". Also included are the DD250 forms, used as an invoice, and the SF298 form, the "Report Documentation Page".

Very truly yours,

Brian J. Fitzpatrick

Brian J. Fitzpatrick

cc: Anna M. Weston,
Administrative Contracting Officer
Program Manager, ONR
Director, Naval Research Laboratory
Defense Technical Information Center
Ballistic Missile Defense Organization

Hexagonal II-VI Structures by Substrate Bandgap Engineering

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A synthesis procedure was developed for bulk ZnMgSSe, using metallic Mg and Se. This is done in the growth crucible in the growth system; this reduces contamination from exposure to the laboratory ambient.

A growth run with 12% Mg and 8% S (nominal) concentrations was done using our zone melting technique in a non-seeding crucible. A 45^{o} cross-section was made by cleaving; it appeared that one grain was about half of the 26 mm (average) diameter boule. No twins were visible at all. It is, of course, desirable to have twin-free material, but, even more importantly, the lack of twins is a strong indication of hexagonal material, a major goal of the program.

Cleavage was facile, with a small number of steps. The maximum size of a facet so far was about 6 x 12 mm; 45^{o} dihedral cleaves (prisms) were seen.

UV-lamp stimulated photoluminescence (PL) was quite uniform, both on the surface and in transmission, although some scattering of transmitted light was seen. PL stimulated by a He-Cd laser (325 nm) on a cleaved sample at 77K showed dominant near-band-edge emission, consisting of both excitonic and donor-acceptor pair transitions; a small amount of deep level emission was seen. The position of the excitonic peak allowed an estimate of the band gap (E_g) to be made. At 77K, it was about 2.96 eV; if the same temperature dependence of E_g as that of ZnSe is assumed, the room temperature gap would be about 2.86 eV.

Conductivity was indicated with a VOM, without deposited contacts. This procedure was done for ZnSe, and the results were checked by Hall measurements, which confirmed a conductivity of 4.65 ohm-cm for ZnSe.

X-ray examination showed sharp reflections in a 2θ scan. The Cu $K\alpha$ doublet was split, with a modulation depth of 84%. Further analysis is in progress.

Etching and surface preparation procedures (in- and ex-situ) were studied, using both ZnSe and ZnMgSe. Molecular-beam-epitaxial growth of ZnSe on ZnSe was achieved, with rocking curve widths of 21-24 arcsec.

Short-term plans are to grow material of both lower and higher magnesium concentrations, and to get the 12% boule fabricated into substrates for MBE growth.

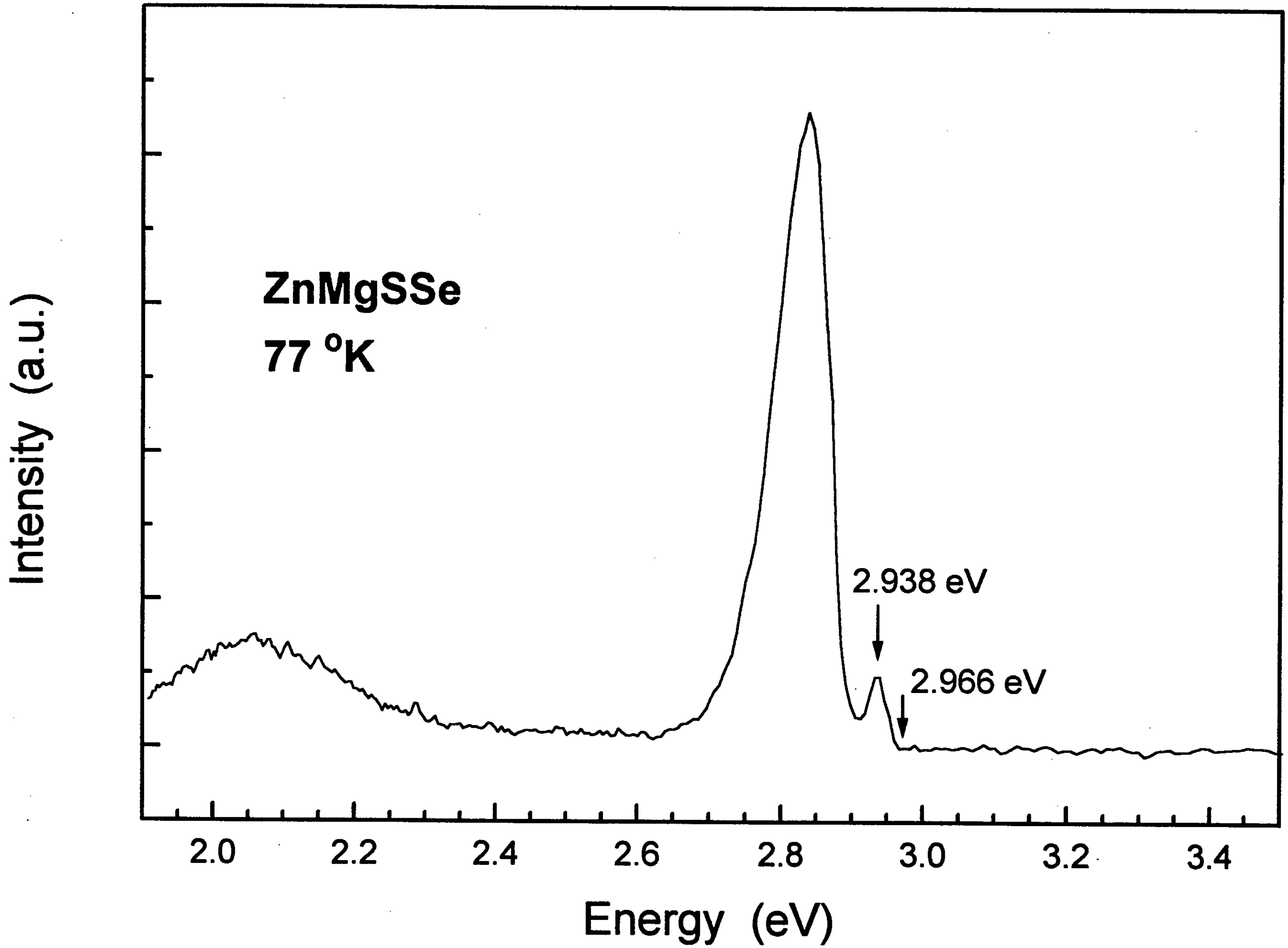

Diagram 1. Photoluminescence of ZnMgSSe. The upward shift of the band gap from ZnSe is clear; the quality is at least comparable to that of good ZnSe.

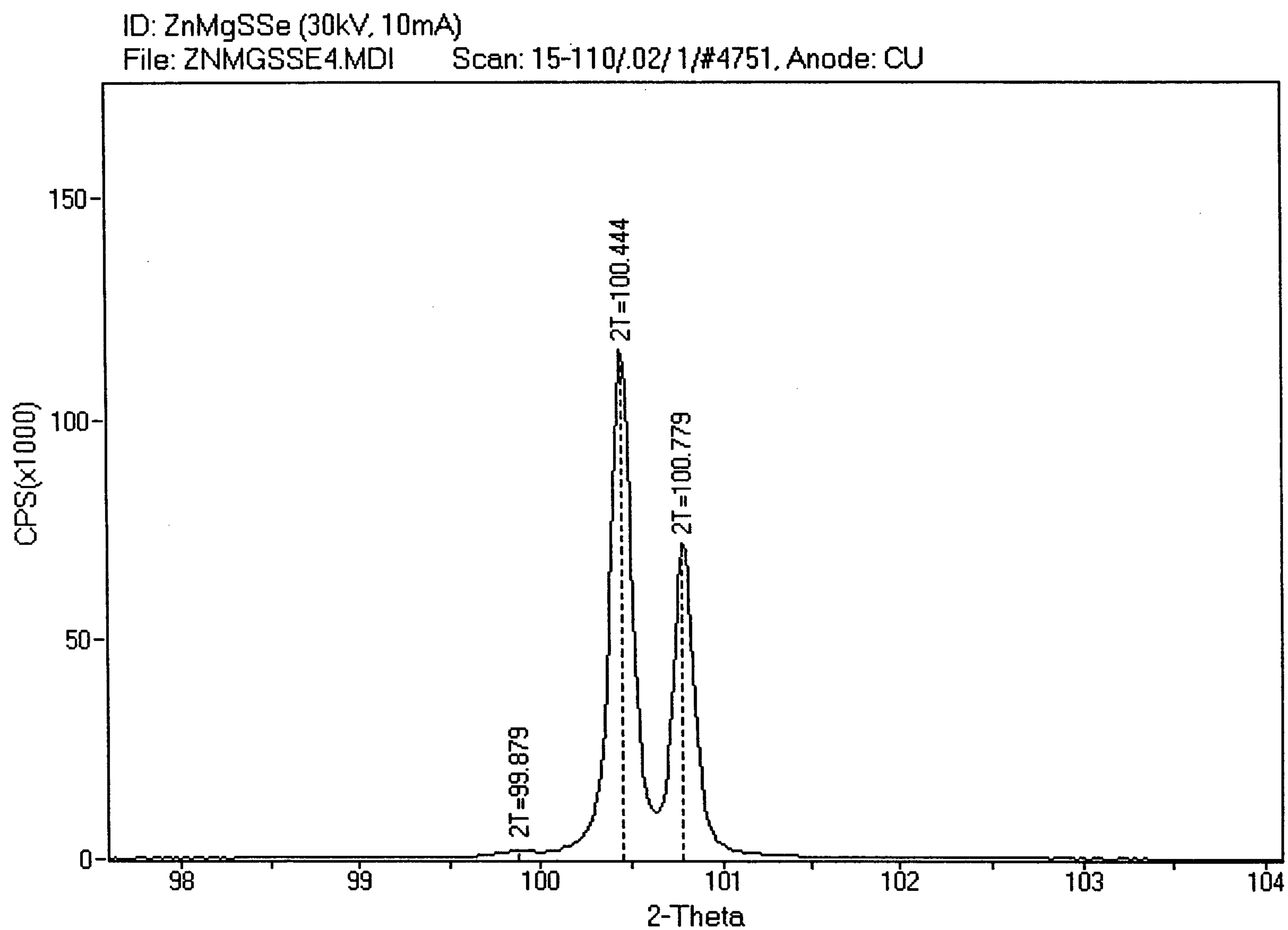

Diagram 2. Portion of x-ray scan of (1120) cleaved face of ZnMgSSe. The 84% modulation depth is measured from the smaller peak.