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THE DEVELOPMENT OF FERROMAGNETIC SPINELS  
FOR OPTICAL ISOLATION AT 10.6  $\mu\text{m}$

Progress Report  
for Period November 1, 1976 - January 31, 1977

Kenneth J. Teegarden

University of Rochester  
Rochester, New York 14627

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### ABSTRACT

During this quarter, measurements of the optical absorption coefficient,  $\alpha$ , of crystals of  $\text{CdCr}_2\text{S}_4$  were measured at  $10.6 \mu\text{m}$  and room temperature, and correlated with growth parameters established during the last quarter. A minimum absorption coefficient of  $15.6 \text{ cm}^{-1}$  was obtained. Procedures for hot forging crystals of  $\text{CdCr}_2\text{S}_4$  were established in preparation for a study of the effect of forging on the optical absorption. Single crystals of  $\text{CoCr}_2\text{S}_4$  were also grown using a technique closely related to that previously employed for  $\text{CdCr}_2\text{S}_4$ .

## THE DEVELOPMENT OF FERROMAGNETIC SPINELS FOR OPTICAL ISOLATION AT 10.6 $\mu\text{m}$

### I. Progress to Date

Single crystals of  $\text{CdCr}_2\text{S}_4$ , described in Table I of the first progress report (COO-EY-76-S-02-4056\*000-1), were polished and the optical absorption coefficient,  $\alpha$ , measured at 10.6  $\mu\text{m}$  and room temperature using a  $\text{CO}_2$  laser, with the results shown in Table I. The best value of  $\alpha$  obtained was  $15 \text{ cm}^{-1}$ . The dependence of  $\alpha$  on method of preparation indicated in the table, provides well-defined guidelines as to the conditions needed to minimize  $\alpha$ .

Although the best values of  $\alpha$  obtained to date are a factor of 100 too high relative to the objectives of this project, they are low enough to enable us to proceed toward another of our most important objectives; namely, a study of the effect of hot pressing on  $\alpha$ . Even with an  $\alpha$  of  $15 \text{ cm}^{-1}$ , a hot pressed disk 1 mm. thick will transmit 22% of incident radiation at 10.6  $\mu\text{m}$ , neglecting reflection losses. This is more than enough to permit measurements of  $\alpha$  in the hot pressed samples, and a detailed study of changes in  $\alpha$  produced by hot pressing .

In compliance with an additional objective of this project, single crystals of  $\text{CoCr}_2\text{S}_4$  have been grown using the technique employed for  $\text{CdCr}_2\text{S}_4$ , except for the substitution of  $\text{CoS}$  for  $\text{CdS}$ . This is an important result because it indicates that we can include this material (which has a higher operating temperature) in our studies with relatively minor changes in procedure.

Preliminary experiments on hot pressing or forging of blanks from crystalline  $\text{CdCr}_2\text{S}_4$  have taken place. These have been directed towards establishing the parameters needed to obtain samples with good density and

mechanical properties, before attempting to fabricate material with the lowest  $\alpha$ . All indications are that we can achieve the conditions needed for good optical quality with present apparatus.

After considerable investigation into alternative equipment, a pulsed  $\text{CO}_2$  laser for conducting damage tests has been ordered. The laser chosen is a TEA laser providing .7 joules in a 40 ns. pulse, Too mode, manufactured by Tachesto, Inc. It is expected early in the next quarter.

## II. Objectives for the Next Quarter

A. During the next quarter absorption measurements will be made on crystals of  $\text{CdCr}_2\text{S}_4$  at  $77^\circ$  K, to establish the value of  $\alpha$  at this temperature.

B. Growth of single crystals of both  $\text{CdCr}_2\text{S}_4$  and  $\text{CoCr}_2\text{S}_4$  will continue, to minimize the value of  $\alpha$  in these materials.

C. Hot forging of both  $\text{CdCr}_2\text{S}_4$  and  $\text{CoCr}_2\text{S}_4$  will continue with emphasis on the optical properties of the forged samples. A study of the change in  $\alpha$  introduced by forging, using crystals described in Table I will be carried out.

The principal investigator will spend 30% of his time on this contract during the next quarter.

TABLE I

CdCr<sub>2</sub>S<sub>4</sub> Room Temperature Absorption Coefficient Results.

<u>Trial</u>	<u>Crystal Growing Method</u>	<u>Range of Polished Crystal Thickness (<math>\mu\text{m}</math>)</u>	<u>Range of absorption Coefficients (<math>\text{cm}^{-1}</math>)</u>
3	Schick & VonNeida method temp.=850°C, mole ratio 2.2/1/ .788 (CdS, CrCl <sub>3</sub> , Cd) exponential cool down	209 - 536	45.0 - 102
4	Trial 3 with temp.=800°C	285	15.6
5	Trial 3 with furnace tilted at 20° angle, 50°C gradient across tube	382 - 534	41 - 72
7	Trial 3 with linear cooling rate	380 - 465	50 - 76
8	Trial 3 with mole ratio 1.5/1.0/ .788 (CdS, CrCl <sub>3</sub> , Cd) keeping amount of CrCl <sub>3</sub> constant	270 - 272	33 - 75.0
9	Trial 8 with mole ratio 2.5/1.0/ .788 (CdS, CrCl <sub>3</sub> , Cd)	412 - 455	19.8 - 43
10	Shick & Von Neida method only temp.=800°C, mole ratio 2.5/1/ .788, linear cooldown, 20° angle tilt, 50°C gradient	283 - 301	63 - 101