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Rockwell International

(6) GROWTH OF TUNGSTEN BRONZE FAMILY CRYSTALS - L

March 18, 1986 In Reply Refer To: SC86-533

Naval Research Laboratory
4555 Overlook Avenue, S. W.
Washington, DC 20375

Attention: Dr. Philipp H. Klein
Code 6822

Subject: Quarterly Technical Report No. 2
For Period 12/01/85 through 02/28/86
Contract No. N00014-85-C-2443
SC5441.QTR

(5) 12/85 - 2/86 : 3/86

In accordance with the requirements stated for Contract No. N00014-85-C-2443, enclosed herewith is Quarterly Technical Report No. 2 for the period 12/01/85 through 02/28/86.

(2) ROCKWELL INTERNATIONAL CORPORATION
Science Center

S Neurgaonkar

Ratnakar R. Neurgaonkar
Manager
Ferroelectric Materials Department

RRN/mrw

enclosure

cc: Attached Distribution List

...covers 11 number(s) NONE
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...tials

(4) QUARTERLY TECH.

(3) N00014-85-C-2443

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MARCH 1986 SC5441.QTR

GROWTH OF TUNGSTEN BRONZE FAMILY CRYSTALS

QUARTERLY TECHNICAL REPORT NO. 2
THE PERIOD 12/01/85 THROUGH 02/28/86

DARPA ORDER NO.: 4540
NAME OF CONTRACTOR: Rockwell International Corporation
EFFECTIVE DATE OF CONTRACT: 05/02/85
CONTRACT EXPIRATION DATE: 01/30/88
AMOUNT OF CONTRACT DOLLARS: $1,245,307
CONTRACT NO.: NOOO14-85-C-2443
PRINCIPAL INVESTIGATOR: Dr. R. R. Neurgaonkar
(805) 373-4109

Professor L. E. Cross
Pennsylvania State University
(814) 865-1181

Sponsored By:

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DoD)
DARPA ORDER NO. 4540

A. OBJECTIVE

The objective of the present work is to develop suitable quality and size $Sr_{0.6}Ba_{0.4}Nb_2O_6$ (SBN) single crystals or thin films that can be used in optical device studies. The second objective of this work is to develop a phenomenological model to explain the correlation between the ferroelectric and optical properties and thereby possibly control and optimize the material performance for device applications.

B. PROGRESS

The tungsten bronze $Sr_{1-x}Ba_xNb_2O_6$ solid solution, $0.75 \geq x \geq 0.25$, is important for various device applications, specifically electro-optic and photorefractive. Since $Sr_{0.75}Ba_{0.25}Nb_2O_6$ (SBN:75) exhibits electro-optic and pyroelectric coefficients greater than any other ferroelectric crystal, it is important to develop this material for our ongoing work on materials for photorefractive and other applications. The recent developments in the crystal growth area indicate that the growth of optical quality Ce-doped and undoped SBN:75 crystals is possible, and crystals as large as 1 to 1.5 cm in diameter have been successfully grown. Since this composition is not congruent melting, it is rather difficult to grow as compared to the congruent melting SBN:60 composition. It is expected that the development of such large electro-optic response (r_{33} = 1400 x 10^{-12} m/V) crystals will have a

significant impact on our various device applications, including electro-optic, photorefractive, and millimeter wave. Currently, efforts are under way to establish its photorefractive properties with respect to cerium dopant concentration.

Another important tungsten bronze crystal, $Sr_{2-x}Ca_xNaNb_5O_{15}$, is being developed for photorefractive and electro-optic applications. This composition is orthorhombic at room temperature and the electro-optic coefficient is estimated to be 1600 x 10^{-12} m/V. The growth of small crystals has been successful and further efforts are under way to perfect growth techniques to develop optical quality SCNN crystals.

Work has continued on the ionic substitution of Ca^{2+} in tungsten bronze $Sr_{0.5}Ba_{0.5}Nb_2O_6$ (SBN:50) ceramic material for pyroelectric detector applications. Simultaneous substitution for both Sr^{2+} and Ba^{2+} results in a substantial decrease in the phase transition temperature T_c, decreasing from 128°C to roughly 50°C for 34% Ca^{2+} substitution. This result is consistent with single ion results where it was found that Sr^{2+} substitution resulted in only a slight increase in T_c, whereas substitution for Ba^{2+} resulted in a considerable decrease in the phase transition temperature. The dielectric loss for these compositions remained low, indicating their qualification for transverse pyroelectric detector applications.

C. MAJOR EQUIPMENT

None.

D. CHANGE IN PERSONNEL

None.

E. TRIPS AND VISITS

In January 1986, Dr. R. R. Neurgaonkar met John Neff of DARPA and gave a briefing on the current status of this program and an outline of future work.

In December 1985, Professor L. E. Cross of Penn State University, visited Rockwell for discussions on the DARPA contract and future work was planned.

F. PUBLICATIONS AND PRESENTATIONS

1. R. R. Neurgaonkar and W. K. Cory, "Progress in Photorefractive Tungsten Bronze Materials, J. Opt. Soc. Am., B/3, 274, (1986).
2. L. E. Cross and R. R. Neurgaonkar, "A Phenomenological Analysis of Tetragonal Tungsten Bronze Ferroelectrics," submitted to J. Mat. Science.

G. FUTURE WORK

Continue to establish the optimum cerium concentration needed to improve the photorefractive response time (~ 1 ms). The effort will be extended to grow optical quality SCNN crystals with and without dopants. Initiate the LPE growth work of bronze

compositions such as SBN, SKN and PBN for electro-optic applications.

H. FUNDING

Contract Estimated Cost	$1,155,549
Fixed Fee	$ 89,758
Total Estimated Contract Price	$1,245,307
Current Contract Funding	$ 370,000
Less Fee	$ 26,772
Available Cost	$ 343,228
Expenditure through 02/28/86 (Cost)	$ 38,641
Balance of Available Funds (Cost)	$ 304,587
Balance of Funding Required to Complete Program	$ 902,079