

A Proposal

***SUMILLIMETER-WAVE MULTIPLIER DEVELOPMENT
FOR THE MILLIMETER ARRAY***

Submitted to:

**National Radio Astronomy Observatory
Central Development Laboratory
520 Edgemont Road
Charlottesville, VA 22903**

Attention:

Dr. Richard F. Bradley

Submitted by:

**T. W. Crowe, Research Associate Professor,
Director, Semiconductor Device Laboratory**

**J. L. Hesler, Co-PI
Research Scientist**

**SEAS Proposal No. EE-NRAO-8184-99
December 1998**

DEPARTMENT OF ELECTRICAL ENGINEERING

SCHOOL OF
ENGINEERING 
& APPLIED SCIENCE

University of Virginia
Thornton Hall
Charlottesville, VA 22903

CONTRACTUAL INFORMATION

A Proposal Submitted to National Radio Astronomy Observatory

Title: Submillimeter-Wave Multiplier Development for the Millimeter Array

Proposal Number: EE-NRAO-8184-99

Date Submitted: December 1998

Offeror: University of Virginia

**Business Office/
Administrative Contact:** Office of Sponsored Programs
P.O. Box 9003
Charlottesville, VA 22906
D. Wayne Jennings, Director
Phone (804) 924-4270
Fax (804) 982-3096
E-mail: dwj@virginia.edu

**Principal Investigator/
Technical Contact:** T. W. Crowe
Department of Electrical Engineering
School of Engineering and Applied Science
Thornton Hall
Charlottesville, VA 22903-2442
Phone (804) 924-7693
Fax (804) 924-8818
E-mail: twc8u@virginia.edu

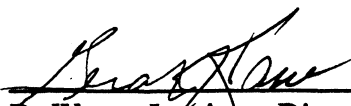
Co-Principal Investigator: J. L. Hesler

Duration: February 1, 1999 - December 31, 1999

Amount: \$80,000

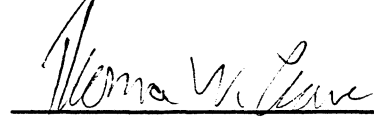
Approvals:

UNIVERSITY OF VIRGINIA



D. Wayne Jennings, Director
Office of Sponsored Programs
Date: 12-4-98

PRINCIPAL INVESTIGATOR



T. W. Crowe
Research Associate Professor
Date: 12/3/98

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BACKGROUND

NRAO's proposed Millimeter Array (MMA) will require the creation of a new class of broadband sources throughout the 300 - 1,000 GHz frequency range. These sources must be highly reliable for use at a remote mountain site, must have large bandwidth without mechanical tuners and must be cost efficient for implementation in the envisioned array facility. The University of Virginia has unique expertise for the fabrication of high frequency, planar GaAs Schottky barrier diodes for frequency multiplication. In addition, we have developed experience in the design and implementation of multipliers and mixers utilizing planar diodes. The purpose of this proposal is to support the ongoing collaboration between UVa and NRAO for the development of frequency multipliers to meet the needs of the MMA.

PROPOSED RESEARCH TASKS

Through this proposal the UVa researchers will collaborate with NRAO on three specific tasks.

- 1) *The supply of discrete planar varactor diodes* to meet the needs of Kamaljeet Saini in the development of millimeter wave doublers. UVa will work with Saini to ensure that his circuit designs conform to existing diode batches when possible. Also, UVa will strive to ensure that the appropriate chips are available for his use in a timely manner.
- 2) *The fabrication of a batch of integrated balanced doubler chips* integrated on quartz substrates by UVA MASTER technology. This will require the extension of the MASTER process to multiplier structures, UVa assistance in the design of the circuit to ensure conformance to the process constraints, the development and procurement of the mask set, and the fabrication and dc evaluation of the chips.
- 3) *The initial development of a quartz based MMIC multiplier technology* in collaboration with Dr. R. Bradley. During this contract the work will involve the fabrication of a test wafer with simple transmission lines, bridges, tee junctions, and integrated capacitors. The test wafer will be supplied to NRAO for evaluation and, if time permits, evaluation will also be carried out at UVa.

PERSONNEL

The primary personnel on this contract will be Dr. T.W. Crowe, PI, Mr. William L. Bishop, Research Scientist and Mr. James Duan, GRA. James Duan is currently completing his MS thesis research on the fabrication of a planar, dual slot integrated mixer. He is very hard working and has acquired most of the fabrication skills required for this work. He will begin his PhD research on integrated submillimeter-wave multipliers in

February, provided that this contract is funded. Bill Bishop will assist James on the development of the fabrication processes and the design of the mask set. Additionally, Steve Marazita, the primary inventor of the Master process, will be available for consultations until he completes his PhD in the spring and Dr. J.L. Hesler will be available to assist with the circuit designs.

IMPACT OF THE PROPOSED RESEARCH

UVa will collaborate with NRAO on the development of broadband submillimeter-wave multipliers for the MMA. At the end of this contract NRAO should have completed tests of initial balanced doublers based on discrete diodes supplied by UVa, have the first prototype of a balanced doubler completely integrated onto a quartz substrate and have a series of test structures to evaluate the performance of various integrated structures necessary for the development of a quartz based MMIC technology. These achievements represent significant progress toward meeting the LO needs of the MMA.

Budget Detail
2/1/99 - 12/31/99

A. Personnel and Benefits

| | | |
|----|---|----------|
| 1. | T. W. Crowe, PI | |
| | 10% effort, 11 mos. @ \$109,900 CY | \$10,074 |
| | Allowance for Salary Increase | 37 |
| | Fringe Benefits @ 23% | 2,325 |
| 2. | J. L. Hesler, Co-PI | |
| | 5% effort, 11 mos. @ \$66,900 CY | 3,066 |
| | Allowance for Salary Increase | 11 |
| | Fringe Benefits @ 23% | 708 |
| 3. | W. L. Bishop, Co-PI | |
| | 10% effort, 11 mos. @ \$67,000 CY | 6,142 |
| | Allowance for Salary Increase | 22 |
| | Fringe Benefits @ 23% | 1,418 |
| 4. | J. Z. Duan, Graduate Research Assistant | |
| | 88 hrs. mo. x \$18.18/hr. x 11 mos. | 17,599 |
| | Allowance for Salary Increase | 64 |

| | |
|--|-----------------|
| SUBTOTAL PERSONNEL AND BENEFITS | \$41,466 |
|--|-----------------|

B. Materials and Supplies

| | |
|---|-------|
| Laboratory Supplies (Mask Set, GaAs Diodes, Quartz Substrates, GaAs Wafers) | 2,600 |
|---|-------|

C. Tuition Remission

| | |
|--|-------|
| In-state tuition remission for graduate research assistant | 4,860 |
|--|-------|

D. Technical Services - Cleanroom Fees

6,050

E. Other Contractual Services

| | | |
|-------------------------|-----|-----|
| 1. Publications | 500 | |
| 2. Copy, communications | 154 | |
| | | 654 |

| | |
|---------------------------|-----------------|
| TOTAL DIRECT COSTS | \$55,630 |
|---------------------------|-----------------|

| | |
|--|---------------|
| F. Indirect Costs - 48% Modified Total Direct Costs | 24,370 |
|--|---------------|

| | |
|--------------|-----------------|
| TOTAL | \$80,000 |
|--------------|-----------------|

BUDGET NOTES

- * Personnel - Faculty appointments are generally effective calendar year (CY) beginning July 1 or Academic Year (AY) beginning September 1. T. W. Crowe, PI - 10% effort for 11 mos.; J. L. Helsner, Co-PI - 5% effort, 11 mos.; W. L. Bishop, Co-PI - 10% effort, 11 mos.; plus increases.
- * Graduate Research Assistants (GRAs) and Undergraduate Research Assistants (URAs) - Costs are estimated based on the minimum and maximum payments for the academic year established by the University Office of the Vice-President and Provost. All compensation in SEAS proposals are within these guidelines. 1 GRA @ 88 hrs. mo. x \$18.18/hr. x 11 mos.; plus increases.
- * Salary Increases - A 4% salary increase is applied to a majority of SEAS proposals, effective 11/25/98, and is accumulated annually from this date. Faculty increases are based on contributions in academic and research areas and are approved by the State of Virginia Budget Office. Staff increases are based on State of Virginia proficiency guidelines. New salaries are given as soon as they are available.
- * Fringe Benefits - The University of Virginia's fringe benefits rates, as they apply to sponsored programs, are proposed as follows: 23% for faculty and professional staff, 31% for classified staff, and 7% for wage employees and summer effort by faculty with AY appointments. Fringe benefits apply to graduate and undergraduate research assistants if not enrolled full time (generally 12 hrs. for undergraduates and 9 hrs. for graduates).
- * Materials and Supplies - Laboratory supplies (mask set, GaAs Diodes, Quartz Substrates, GaAs Wafers).
- * Tuition Remission - Effective September 1, 1990, it is the policy of the University of Virginia to provide tuition for graduate research assistants as partial compensation for services.
- * Laboratory Fees for Cleanroom Facility - The Semiconductor Device Laboratory's Cleanroom facility is provided for sponsored research programs and its operational costs must be obtained from individual research grants and contracts requiring use of this facility. Fees are based on usage of the facility in the following manner: \$500 per month for those needing direct access to the cleanroom; \$200 per month for those needing access only to areas outside the cleanroom. \$500 per user month x 1.1 users x 11 months = \$6,050.
- * Publications - Publications and page charges in related technical journals.
- * Other Costs - Estimated costs for photocopying, long distance phone and FAX, reports preparation, etc. are based on prior SEAS research experience.
- * Indirect Costs - The University of Virginia's negotiated MTDC Indirect Cost rates with DHHS per agreement of 7/26/98 are: 7/1/98 - 6/30/2002, and until further amended, 48% "on campus" and 23.6% "off-campus". (Note: The MTDC base consists of total direct costs less individual equipment items in excess of \$2,000, alterations and renovations, patient care costs, stipends, tuition remission and rental costs of off-campus facilities.)