

REQUEST FOR PROPOSAL

FOR

**FABRICATION OF SILICON CARBIDE PROTOTYPE MIRROR
SEGMENTS FOR THE
THIRTY-METER TELESCOPE**

AURA, Inc.

**Operating the
National Optical Astronomy Observatories
Tucson, Arizona**

PROPOSALS DUE: 3:00 P.M (MST) MONDAY, February 23, 2004

Prepared by:

**National Optical Astronomy Observatory
Contracts Office
for the
Association of Universities for Research in Astronomy, Inc.
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January 26, 2004

SECTION III

A. SCOPE OF WORK

1. General

1.1 Contractor shall review the Prototype Segment Specification provided in this scope of work and develop a Prototype Segment detailed design consistent with the Prototype Segment Specification. The Contractor is encouraged to work with AURA to propose refinements, where modifications could provide higher performance lower cost or both. The final Prototype Segment Specifications, if different from the specifications contained within this Scope of Work, shall be approved by AURA before the Prototype Segments are fabricated and shall be included in the final report as specified in section 1.4, below.

1.2 Contractor shall prepare a quality assurance plan that details the inspection and testing procedures to be used to determine the compliance of the Prototype Segment with the requirements of the Prototype Segment Specification. The quality assurance plan shall also contain analysis of the accuracy with which the material properties outlined in the Prototype Segment Specification can be measured.

1.3 Contractor shall fabricate, and deliver to AURA, two (2) Prototype mirror Segments based on the final Prototype Segment Specifications described in section 1.1, above.

1.4 Contractor shall prepare and deliver a report on the fabrication of the Prototype which contains the information outlined in sections 1.1 and 1.2 above. The report shall consist of the following sections:

- a. An executive summary suitable for public release (see Section 3, below, on Proprietary Information). This summary must include, at a minimum: (1) a pictorial (i.e., not dimensioned) drawing of the Prototype Segment; (2) a description of the properties of the material in the Prototype Segment; (3) a general description of the process employed in manufacturing the Prototype Segment; (4) a summary of the fabrication schedule; (5) a description of the Contractor's relevant experience.
- b. A description of the Prototype Segment design on which the study is based, including a dimensioned drawing.
- c. A description of the material properties of the Prototype Segments including an estimate of the uncertainty of these properties and an estimate of the variation of these properties between Segments.
- d. A description of the manufacturing process that was used to produce the Prototype Segments.

1.5 Contractor shall fabricate, and deliver to AURA, four (4) sample coupons. These sample coupons shall have the following properties:

- a. The material properties and the surface treatments of the coupons shall be identical to the Prototype Segments.
- b. The size of the sample coupons shall be approximately 50 mm square and 5 mm thick
- c. One 50mm x 50 mm face shall be polished flat with a micro-roughness below 20 angstroms.

2. Segment Delivery Schedule and Location

2.1 Delivery of the Prototype Segments and the final report shall be no later than six (6) months after award of contract. The delivery location shall be:

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950 N. Cherry Avenue
Tucson, AZ 85726-6732

3. Proprietary Information

3.1 AURA will protect the proprietary information of Contractor, provided it is clearly marked as such. Each page of the report that contains proprietary information must be so indicated by a legend at the bottom. Note that it is not AURA's intention that Contractor divulge detailed manufacturing process information that would be considered a "trade secret", and such information should not be included in the report. AURA simply needs sufficient information about process steps to be able to judge the credibility of the plan and estimate any associated cost and schedule risks.

3.2 AURA needs basic information about Segment manufacturing feasibility that can be discussed in open meetings, which shall include, at minimum, the information described in Section 1.4-a.

3.3 AURA reserves the right to seek the advise from optical polishers in determining the polishability of the proposed Prototype Segments.

4. Meetings - Reviews

4.1 There shall be a review meeting prior to any fabrication activity. This meeting shall be held at a time and location to be mutually agreed upon between AURA and the Contractor. The purpose of this meeting will be to review and approve the final Prototype Segment Specification, any modifications that have been proposed by the contractor, and to review and approve the Contractors quality assurance plan.

4.2 A review meeting shall be held at Contractor's facility to inspect the completed Prototype Segments prior to their shipment. This meeting shall occur not later than two weeks prior to their shipment to AURA. The Contractor shall present AURA with a draft of the final report. AURA representatives shall have an opportunity to comment on the draft. These comments shall be taken into account in the delivered final report.

4.3 AURA reserves the right to call and conduct meetings, at the Contractor's location, as it may deem necessary for the purposes of review, discussion, presentation or coordination of the work.

SECTION III

B. PROTOTYPE SEGMENT SPECIFICATION

1.0 Scope. a. The Prototype Segments will be used to evaluate the suitability of the specific Silicon Carbide technology for the Segments to be used in the Thirty Meter Telescope.

b. Except as expressly provided otherwise herein, Contractor shall have sole responsibility for ensuring that the Prototype Segments comply with all requirements set forth in this Prototype Segment Specification.

1.1. Definitions

1.1.1 Depending on the context, the terms "Silicon Carbide" or "SiC" may refer either to pure silicon carbide, or to a composite material composed largely of silicon carbide and having material properties similar in most respects to pure silicon carbide.

1.1.2 The term "Segment" shall mean a hexagonal mirror blank ready for optical finishing that is intended for use in the Thirty Meter Telescope.

1.1.3 The term "Prototype Segment" shall mean a round mirror blank ready for optical finishing that meets the requirements in this Prototype Segment Specification.

1.2 Applicable Documents. a. The following documents are attached and are made part of this Prototype Segment Specification:

a. NIO-0100-0001 (initial release), 300 mm Prototype Segment.

b. Contractor acknowledges that it has received adequate copies of the Drawings. Contractor shall ensure that all items produced by it under the subsequent Contract conforms in all respects to the requirements and specifications provided in the specification and drawings.

1.3 Environments.

1.3.1 Operating Environment. The Prototype Segment shall be capable of sustained and continuous operation in complete conformance to the requirements of this Prototype Segment Specification throughout the expected life of the observatory while being subjected to any combination of the following environmental conditions.

Altitude: sea level to 5000m
Temperature: -25 to +25 C
Relative Humidity: 0 to 100% condensing
Wind speed: 0 to 20 m/s
Orientation: Any

1.3.2 Survival Environment. The Prototype Segment shall meet the requirements stated in 1.1.1 above without damage, after being subjected to any combination of the following environmental conditions for any duration for any number of occurrences over the expected life 1.7.

Altitude: sea level to 15500m
Temperature: -25 to +50 C
Relative Humidity: 0 to 100% condensing
Wind speed: 0 to 40 m/s
Orientation: Any
Seismic: 10G in any direction

1.4 Material properties.

1.4.1 The Prototype Segments shall be made from Silicon Carbide.

1.4.2 The density of the bulk material in the Prototype Segments; shall be as defined by the Contractor in the Proposal Documents. The maximum porosity expected shall be as defined by the Contractor in the Proposal Documents.

1.4.3 Young's Modulus of the bulk material in the Prototype Segments, and the Poisson's Ratio of the bulk material in the Prototype Segments shall be defined by the Contractor in the Proposal Documents.

1.4.4 the coefficient of thermal expansion of the bulk material in the Prototype Segments shall all be as defined by the Contractor in the Proposal Documents in the following terms:

- a. Absolute value of the mean linear coefficient of thermal expansion over the range of -5 to 5 °C, and $+20$ to -5 °C.
- b. Homogeneity as defined by 3σ , σ being the standard deviation over the sample, within each Prototype Segment. The requirement for the full size Segments will be $<0.01 \times 10^{-6}$ /°C.
- c. Uniformity of the average coefficient of thermal expansion from one Prototype Segment to the next, over the range of -5 to 5 °C. The requirement for the full size Segments will be a maximum variation between Segments, as defined by 3σ , σ being the standard deviation over the sample, $<0.005 \times 10^{-6}$ /C.
- d. The average material coefficient of thermal expansion shall be measured and recorded

for each delivered Prototype Segment, within an accuracy better than $0.005 \times 10^{-6} / ^\circ\text{C}$.

1.4.5 The maximum admissible tensile stress, to be considered as additional to internal residual stresses, shall be specified by the Contractor in the Proposal Documents.

1.4.6 Fracture toughness shall be specified by the Contractor in the Proposal Documents.

1.5 Surface quality

1.5.1 a. Cracks or fissures shall be repaired by grinding with minimal material consumption and no sharp edges.

b. No repairs shall be required or allowed on the front surface of any Prototype Segment.

c. Maximum number of repairs shall be 2 per Prototype Segment.

d. Maximum individual repair area shall be 100 mm^2 (as projected onto the surface through which the repair is ground out).

e. The maximum individual repair depth (measured from surface through which repair is ground out) is $1/3$ of material thickness at repair location .

1.6 Mass. The maximum mass variation between any two Prototype Segments shall be less than 5%.

1.7 Lifetime The Prototype Segments shall be capable of withstanding any number of re-coatings and any combination of Operating and Survival Environments for the expected lifetime of the observatory, 50 years, without degradation to any of the Prototype Segment Specifications.

1.8 Polishing The Prototype Segment front surface shall be capable of being polished to a flat (plano) figure with minimum material removal. The material shall be capable of being polished to a surface roughness of less than 20 angstroms rms.

1.9 Coating

1.9.1 The Prototype Segments shall continue to comply with all the requirements of the Prototype Segment Specification after any number of repeated cleaning, coating and coating removal cycles over the lifetime of the Prototype Segments. Materials that may be used for such procedures, without limitation, include:

- a. Hydrochloric acid
- b. Cupric Sulfate
- c. Potassium Hydroxide
- d. Nitric acid
- e. Ceric Ammonium nitrate
- f. Calcium carbonate
- g. Hydrocarbon solvents such as methanol, propanol and acetone
- h. Potassium ferrocyanide and Sodium thiosulfate solutions