

**Attachment Number 1 to the  
Memorandum of Understanding (LIGO-M970056-00-M)  
between the  
Shanghai Institute of Optics and Fine Mechanics (SIOM)  
of the Chinese Academy of Sciences, Shanghai, China  
and the  
Laser Interferometer Gravitational Wave Observatory (LIGO) Project  
July 1, 1997**

This Attachment to the Memorandum of Understanding LIGO-L970056-00-M describes the activities of the Shanghai Institute of Optics and Fine Mechanics (SIOM) of the Chinese Academy of Sciences, Shanghai, China in developing high quality, large Sapphire crystals for LIGO. The period of performance for the activities in this Attachment is from July 1, 1997 to December 31, 1998. This period may be modified by agreement to a revision of this Attachment.

1. The goal of this work is to produce high quality, large Sapphire crystal blanks, as specified, for test masses required by LIGO. The ultimate specification of LIGO test masses would require Sapphire crystal blanks of:
  - a. Diameter 25 cm and length 10 cm with Sapphire's c-axis along the cylinder axis with an alignment of  $< 100 \mu\text{rad}$ , and
  - b. Absorption of  $< 5 \text{ ppm/cm}$  and homogeneity of  $< 5 \times 10^{-7}$  at wavelength of 1064 nm within the central 8 cm.
2. This task will be led by Peizhen Deng and Jun Xu for SIOM and by Ren-yuan Zhu for LIGO.
3. Phase I Work Plan and Deliverables- The tasks to be carried out and the methods for so doing are:
  - a. SIOM will deliver three Sapphire crystal blank samples of diameter 11 cm and length 8 cm with the c-axis along the cylinder axis, low absorption ( $< 10 \text{ ppm/cm}$ ) and good homogeneity ( $< 5 \times 10^{-6}$ ) at a wavelength of 1064 nm within the central 5 cm. Sample delivery will start around the end of 1997 and will be complete by June 1998.
  - b. SIOM will provide a feasibility study of Sapphire test masses required by LIGO.
  - c. LIGO will provide technical evaluation of Sapphire samples.

4. The SIOM LIGO group will at times send their scientists to Caltech to work on LIGO experiments and coordinate activities with SIOM. The number will be flexible according to needs, subject to approval by the LIGO Project. Financial support of these scientists will be determined by mutual agreement.
5. Technical, Schedule and Cost Reporting - The status of the work will be reviewed in a monthly teleconference involving all interested parties from SIOM and LIGO. The emphasis of these meetings will be on technical and schedule issues. In addition, the progress of Phase I Sapphire R&D will be reviewed in June 1998. A final evaluation of the results of Phase I R&D will take place in December, 1998, and a written report for Phase I will be submitted to the LIGO Project in December, 1998. Preliminary plans for Phase II R&D will be discussed in June 1998, and will be finalized in December 1998.
6. Cost - The LIGO Project will provide US\$50,000 for Phase I R&D funds towards Sapphire Development to SIOM.
7. Intellectual Property Rights - The rights to intellectual property developed under this Attachment will be subject to the US National Science Foundation Grant Policy as indicated in Section 730, Intellectual Property.
8. The growth technology of Sapphire crystals is the property of SIOM. During the course of this project, information related to Sapphire crystal growth may be disclosed to LIGO scientists with an understanding that they will not pursue Sapphire crystal growth and that they will treat this information with due care and discretion.

Approved:

Barry Barish  
Barry Barish  
LIGO Principal Investigator

19 June 97.  
Date

Ren-yuan Zhu  
Ren-yuan Zhu  
LIGO Representative

6/30/97  
Date

Bill Kells  
Bill Kells  
LIGO Representative

30 June 1997  
Date

Hu Qiquan  
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SIOM Deputy Director

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Jun Xu  
SIOM Sapphire Development Group

Jun Xu  
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30 June 1997  
Date