Design and Manufacture of Laser Retro-reflector Arrays for LEO and HEO Satellites at SHAO

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Abstract: The first set of Laser Retro-reflector Arrays (LRA) was successfully made and onboard Chinese spacecraft at the altitudes of 330km by Shanghai Astronomical Observatory (SHAO) in 2002. Up to now SHAO has designed more than twenty sets of LRA for the Chinese-made satellites with different orbital altitudes of 330-36000 km. The smallest LRA for LEO was 400 grams and the largest one for GEO was 4.85 kg. The effective reflective area is from less than 8 cm^2 to near 800 cm^2. And two sets of LRAs onboard LEO have been exported to South Korea. SHAO have also manufactured LRA for laser radar at the mission of Chinese first spacecrafts docking to measure the distance between two docking spacecrafts. All LRAs are passed the space environmental simulation testing to insure the stability of products. It has been shown from the measuring results that the performances of LRA are good.

1. Introduction

Since 1999, Shanghai Observatory started designing laser retro-reflector arrays (LRAs) for the Chinese space missions. In 2002, the first set of LRAs made by SHAO successfully onboard Chinese LEO spacecraft (330km). In 2003, the first set of LRAs by SHAO onboard the Chinese HEO satellite (36,000km). In 2010, the LRAs for the mission of Chinese first spacecrafts docking were designed, and accurately measurement for the distance of two spacecrafts was successful. The following shows the products of LRAs at Shanghai Observatory.

Fig.1 The products of laser retro-reflectors made by Shanghai Observatory

Up to now, more than 20 sets of LRAs at Shanghai Observatory designed for Chinese space mission. The weight of the min. one is about 400g onboard LEO satellites and the max. one about 4.85kg onboard HEO for SLR.

2. The main performances of LRAs of Shanghai Observatory

Type of satellite orbit / LRAs	Satellites	Orbital altitude /km	Size of LRAs / mm	Size of corner cubes / mm	Coating	Weight / kg	Year
LEO (semi-spherical base) for SLR	Shenzhou-4	330	¢ 200	¢ 30	none	0.85	2002
	Shiyan-1	790	¢ 130	¢ 33	Sliver	0.4	2007
	South Korea	/	¢ 200, ¢ 130	¢ 30, ¢ 33	Sliver	0.4	2003, 2011
HEO (semi-spherical base) for SLR	Compass MEO	21,500	326(w) 280(h)	¢ 33	none	4.45	2007~ 2012
	Compass GEO	36,000	490(w) 280(h)	¢ 30, ¢ 33	none	4.37, 4.85	2003, 2009~ 2012
LEO for spacecraft docking	TianGong-1	350	30(L) 422(W) 169(H)	¢ 33	Sliver	8.6	2011

3. The performances test of LRAs

Shanghai Observatory had established the procedure of performances test to insure the ability of reflection, including dihedral offset, optical reflectivity (532nm), diffraction Pattern etc. Fig.2, Fig.3 and Fig.4 show the ZYGO interferometer, test of Diffraction Pattern of a corner cube in the laboratory of Shanghai Observatory and the performances test of LRAs under the simulated space conditions.

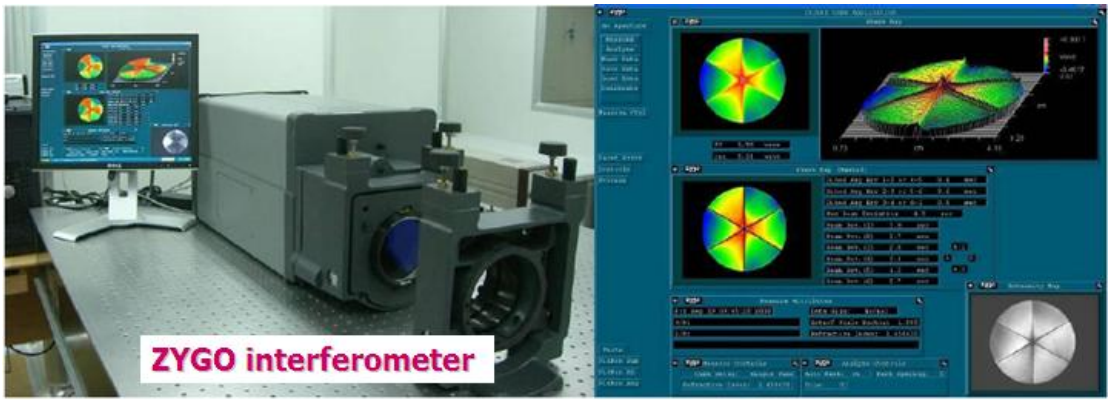

Fig.2 The ZYGO interferometer in Shanghai Observatory

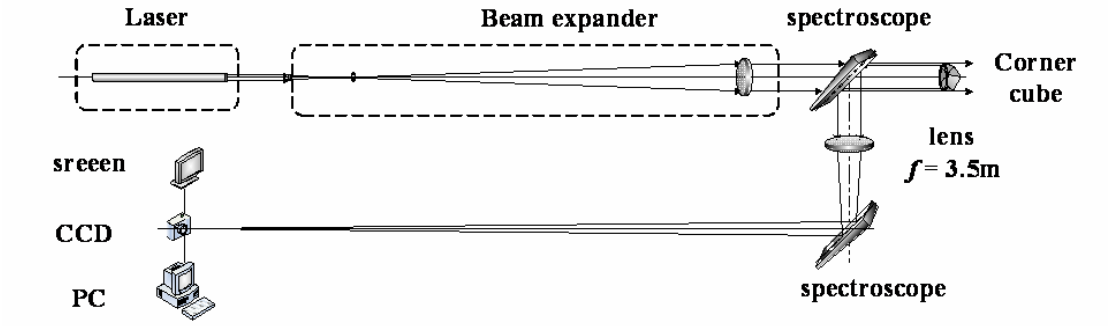

Fig.3 The test of Diffraction Pattern of a corner cube

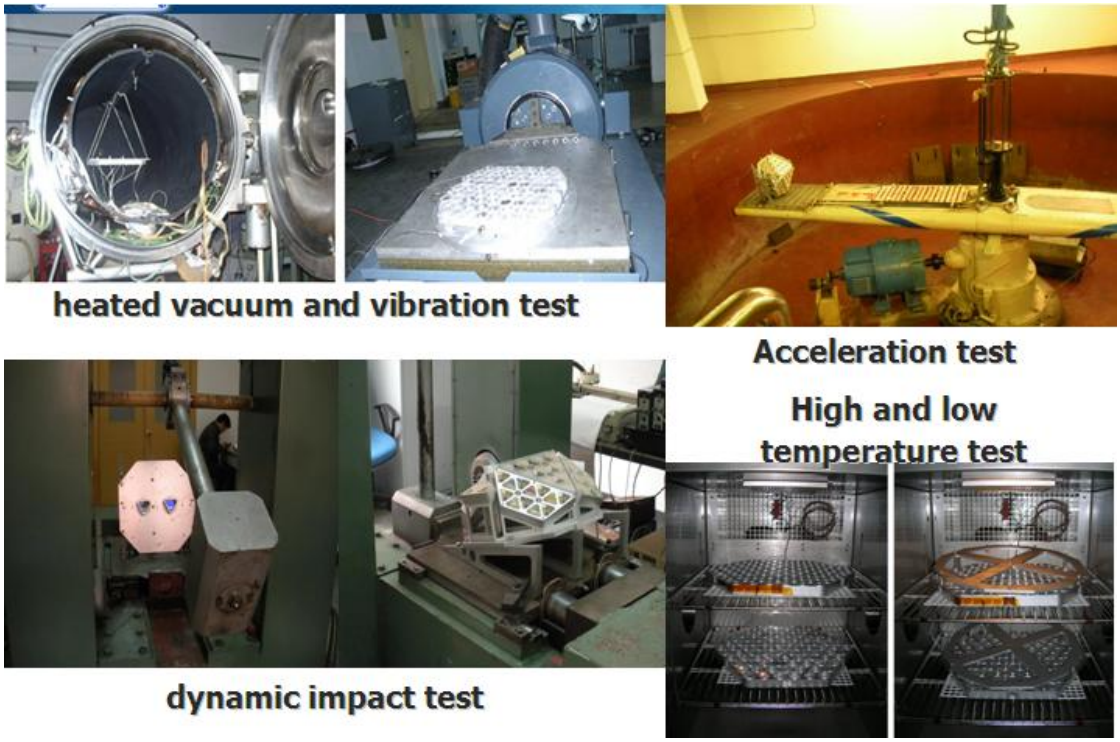

Fig.4 Performances test of LRAs under the simulated space conditions

4. Future development of LRAs at Shanghai Observatory

Based on the past experiences of LRAs design and by using more precise testing equipments in the future, the improvements of LRAs in the aspects of light weight, compact, high reflective ability for Chinese future LEO and HEO satellites will be performed. To meet the requirements of Chinese deep space development, the LRAs design for Chinese Space VLBI satellites with the farthest distance of more than 60,000km will be achieved in the next five years. And the design of lunar LRAs will also be investigated for Chinese Chang'E lunar exploration mission.