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Develpoment of the retro-reflector on the moon for the future lunar laser ranging

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Lunar Laser Ranging (LLR) data are important for the investigations of the lunar rotation, tide, and lunar deep interior structure. The range accuracy of LLR has been less than 2 cm for the last 20 years due to the progress of laser transmit/receive system on the ground stations and the atmospheric signal delay model, however, one order or more accurate ranging than 2cm is needed for better understanding of the lunar deep interior. Murphy et al. [1] showed that the main source of range error comes from the fact that the existing retro-reflectors on the lunar surface are array-type ones which consist of arrays of small corner cube prisms (CCP).

To overcome this problem, large single aperture retro-reflectors are necessary with very small offset angles (dihedral angle offset; DAO) between reflecting surfaces, which must be employed for the management of the 'velocity aberration problem' [2,3]. We are developing 'single aperture and hollow' retro-reflector (corner cube mirror; CCM) to be aboard future lunar landing missions. The aperture of CCM is 20cm because the reflection efficiency of that size is found to be higher than that of Apollo 11 array CCP, and 'ultra low expansion glass-ceramic (CCZ-EX; OHARA Inc.)' or 'single crystal Si' are selected for candidate material of CCM in terms of small |CTE|/K (Thermal expansion coefficient over thermal diffusivity). The optical performance of CCM deformed by lunar gravity or solar illumination in the gimbal model will be presented for some cases. We are now trying to fabricate CCM test model made from CCZ-EX using the optical contacting method that is applicable to single crystal Si, too.

References: [1] Murphy T. et al. (2008) PAPS, 120, 20-37. [2] Otsubo T. et al. (2010) Adv. Space Res., 45, 733-740. [3] Otsubo T. et al. (2011) Earth Planet Space, 63, e13-e16.

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