[SSC22-WKIII-04]

1.5 size 350-950nm hyper-spectral camera optical and mechanical design without MTF degradation in the temperature range -100 to 300 ℃

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ABSTRACT

1.5U sized hyper-spectral camera has been developed to be equipped in three-unit sized CubeSat. Even though this payload is developed for Cubesat, the optical and mechanical structure is designed for harsh environmental conditions to be equipped in the other satellite types. The optical performance of the payload is assessed using Modulation Transfer Function (MTF) in 350–950nm. The MTF is optimized with volume and MTF requirement constraints by CODE-V in the wavelength range. The constraints are 1.5U volume, the curvature ranges of fabricable aspheric design, fabrication errors, and the temperature variation in space. The 1.5U size constraint is defined to 100mm×100mm×145mm which includes 1U for inside and 0.5U for outside of the satellite, and the diameter of the primary mirror is 80 mm. The 0.5U space is offered in a Poly-Picosatellite Orbital Deployer (P-POD). In order to shorten the camera tube length, the lens and mirrors should be asphere and the fabricability of the optical elements with acceptable errors should be checked. The temperature range for describing harsh space environments is assumed as –100℃ to 300℃, and the maximum invar tube length expansion by the 400℃ difference is 304㎛. The temperature variation degrades the MTF and tolerance range of the drawing, so the degradation is compensated with the other length variations of mechanical elements in the optical system.

INTRODUCTION

[1] and [2] classified CubeSat thermal control methods into passive and active. Passive thermal control techniques are Multi-Layer Insulation (MLI), louvers, paint coating, Sun shields, radiators, heat pipes, and thermal strap. These techniques utilize heat conduction, radiation insulation, conduction insulation, and black body radiation, and are not requires energy consumption. However, active control techniques increasing or decreasing CubeSat temperature by energy consumption. Heater and radiometer have been used to increase temperature for battery temperature control, evaporization, and payload temperature control. In order to decrease CubeSat temperature, crycooler and thermoelectric cooler have been used to maintain its temperature. Phase Change Thermal (PCM) control system for CubeSat was suggested to combine increasing and decreasing techniques [3].

Temperature control for maintain performance paperes, Problem: system is complicate

Sol: thermal compensation by material selection

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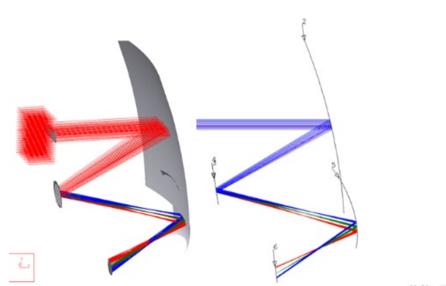
DESIGN DRAFT

Writing is required. It will be done before July 15



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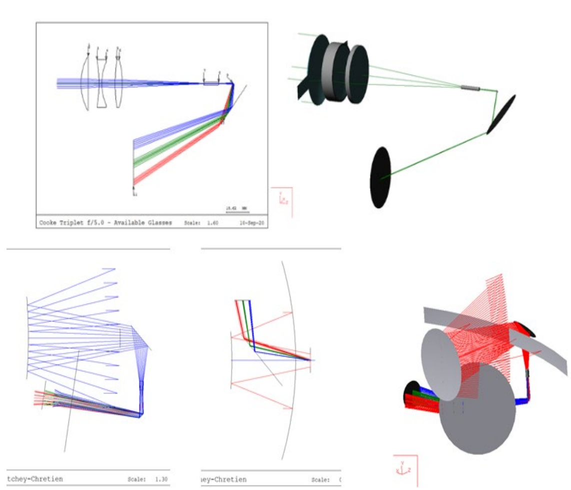

System types	Second mirror	Primary mirror	System size	Grating Type
TMA	X	5cm	$6 \times 6 \times 6$	Asphere
Cassegrain	O	7cm	$9 \times 10 \times 10$	Planar or Sphere
Triplet	X	3cm	$5 \times 10 \times 10$	Planar or Sphere

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CONSTRAINTS AND PROTOTYPE

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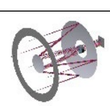
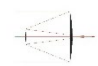
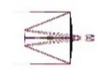
시작 면	끝 면	두께 (mm)
주경 전면	주경 후면	20
주경 후면	부경 전면	100
부경 전면	부경 후면	20
부경 후면	접안렌즈 전면	80
접안렌즈 전면	접안렌즈 후면	5
접안렌즈 후면	거울	x
거울	상면	$80-x$

3D plot	xy plane plot
	

xz plane plot	yz plane plot
	

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ASPHERIC CASSEGRAIN TELESCOPE

종류	제작 공차 원인	재료
거울	곡률, Conic constant, 두께, 평탄도, 기울기	Zerodur
렌즈	곡률, Conic constant, 두께, 평탄도, 기울기	HPFS7980
경통	평탄도, 두께	Invar
구조	평탄도, 두께	Invar

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TOLEREANCES

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우주환경 온도 (-100 ~ 300 ℃)	
재료	열팽창 계수
Zerodur	4.5×10^{-6} 1/℃@ 275℃
HPFS7980	0.57×10^{-6} 1/℃@ 0−200℃
Invar	7.6×10^{-6} 1/℃@ 300℃

시작 면	끝 면	거리 (mm)	재료	400℃ 변화	비율 (%)
주경 전면	주경 후면	20	Zerodur	36㎛	0.18
주경 후면	부경 전면	100	Invar	304㎛	0.304
부경 전면	부경 후면	20	Zerodur	36㎛	0.18
부경 후면	렌즈 전면	80	Invar	243.2㎛	0.304
렌즈 전면	렌즈 후면	5	HPFS7980	1㎛	0.02
렌즈 후면	상면	80	Invar	243.2㎛	0.304

Qualification

Quantification

THERMAL ANALYSIS OF CASSEGRAIN TELESCOPE

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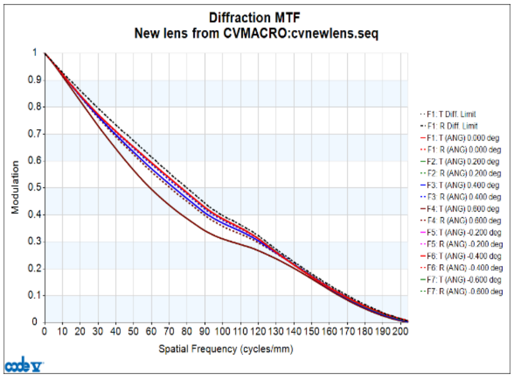

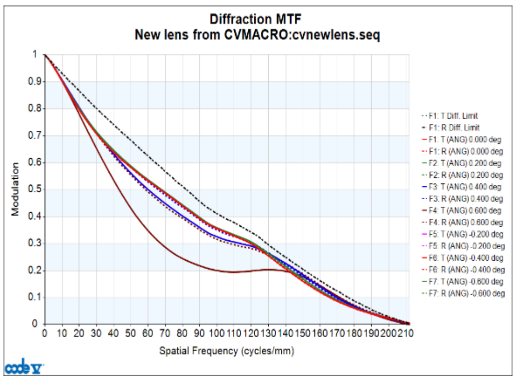

성분	공차 값 (근사)
최대 곡률 공차	9.7mm
최소 곡률 공차	1.3mm
최대 Conic 공차	0.32
최소 Conic 공차	0.06
최대 두께 공차	4mm
최소 두께 공차	0.25mm

Qualification

Quantification

THERMAL ERROR COMPENSATION OF CASSEGRAIN TELESCOPE

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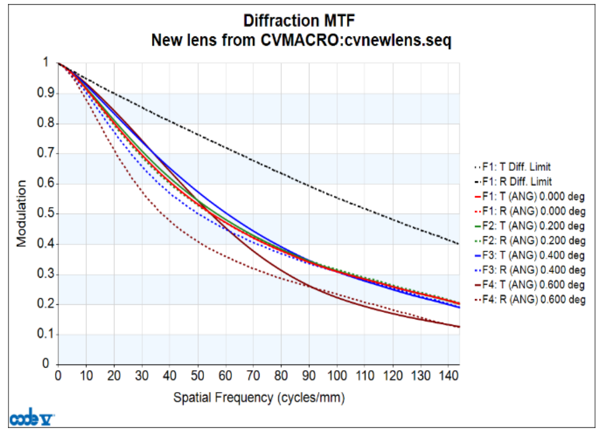
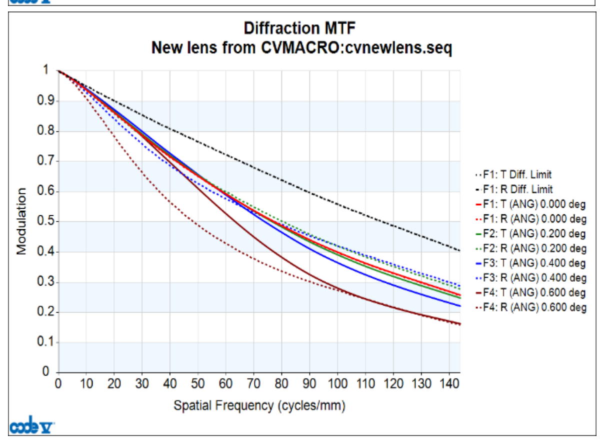
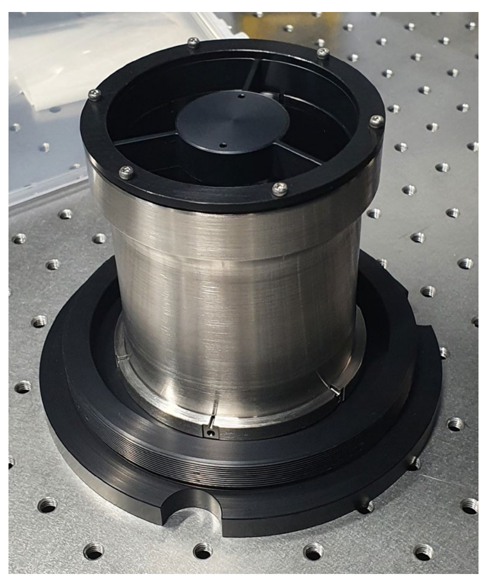
Qualification

Quantification

태양 복사로 인한 위성체 온도변화량 (20~ 300 ℃)			
Material	h	Linear	Quadratic
Invar	4.84×10^{-7}	-1.51×10^{-8}	1.52×10^{-10}
Al7075-T6	2.09×10^{-6}	1.39×10^{-8}	8.83×10^{-12}







GRATING PROPERTY

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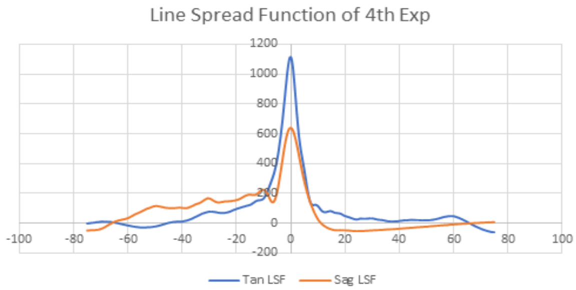
Qualification



THERMAL ANALYSIS OF HYPERSPECTRAL CAMERA

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Qualification

Quantification

THERMAL ERROR COMPENSATION OF HYPERSPECTRAL CAMERA

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Qualification

[1]. Poghosyan, A., and Golkar, A. "CubeSat evolution: Analyzing CubeSat capabilities for conducting science missions," *Progress in Aerospace Sciences* Vol. 88, 2017, pp. 59-83.

[2]. Mishra, H. V. "Thermal Control Subsystem for CubeSat in Low Earth Orbit," *International Research*, 2018.

[3]. Shinde, P., Fernandez, A., Tansel, I., and Tosunoglu, S. "Active thermal control system for CubeSat," *30th Florida Conference on Recent Advances in Robotics*. 2017.