Mirror Tech Days 2015



Tool Influence Function (TIF) Characteristics of SiC mirrors

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- Optical fabrication of coupon and 300 mm SiC materials
- **TIF characteristics of various SiC materials**



Preparation of environmental testing

Result and Implication







PROGRAM OVERVIEW





1. Program Overview

- Collaboration with NOAO, KASI and GO
 - KASI: Total responsibility of development for SiC polishing and measurement
 - NOAO: Evaluation and technical assistances
 - GO: Polishing and measurement
- Study Period: 2014.1.1 ~ 2015.12.31 (2 years)
- Deliverables: 3 SiC polished mirrors







- Surface quality
 - Surface figure error: less than 20 nm RMS
 - Surface roughness : less than 2 nm RMS
 - Surface imperfection: less than 40 um scratch, 500 um dig
 - Subsurface damage: use best efforts to minimize
 - Structure function: provide (determined by collaboration with NOAO)
- Measurements
 - Surface figure error was measured by appropriate mount specified with the optical surface facing vertically upward supported on three tooling balls placed under the 12 mm diameter holes on the rear surface of the mirror



1. Program Overview

Risk and effectiveness	Prob.	Imp.	Mitigation plan	Conso rtium	Status (Due)
 Rick: Environmental testing Not fully equipped facility in KASI 			 Preparation of the facility Find funding sources to purchase 	KASI NOAO GO	Finish ('15.09)
 Effectiveness Not fully certified mirrors in operation condition 	L	Μ	 Adjust testing plan Mild temperature condition 	NOAO KASI	Finish ('15.11)







OPTICAL FABRICATION OF COUPONS AND 300 MM SIC MATERIALS





2. Fabrication

SiC collaboration (KASI-NOAO)



3 SiC blanks with coupons shipped to KASI (1/2014)



Mirror ID numbers engraved; Coupon IDs printed at the back.

SiC Mirror and Coupon ID numbers

2 2	Mirror Part	Mirror Serial	Coupon	Coupon 2
SSG	7090401	N/A	325	337
POCO	19752	21347	P01	P02
CoorsTek	6130317	7851805-4	3	4





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2. Coupon Polishing - configuration



NOAO

Slurry grain size - 1st stage: 9, 1 um - 2nd stage: 6, 1 um Rotation speed - Cam: 21 rpm - Spindle: 64 rpm









2. Coupon Polishing - equipment







2. Coupon polishing - Figure error of SSG







2. Coupon polishing - Surface roughness

Req. = 2 nm rms







3. Φ 300 mm SiC polishing - configuration













3. Φ 300 mm SiC mirror polishing - equipment

Polished by IRP



Measured by ASI

- Optical surface feature using ASI with 3 kinematic mount
- measured by appropriate mount specified with the optical surface facing vertically upward supported on three tooling balls placed under the 12 mm diameter holes on the rear surface of the mirror





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3. Φ 300 mm SiC polishing – surface figure

- Polished optical surfaces (work in progress for SSG)
 - Coorstek, POCO, SSG (requirement: < 20 nm rms)



3. Φ 300 mm SiC polishing – surface roughness

• Surface roughness measurement (work in progress)







TIF CHARACTERISTICS OF VARIOUS SIC MATERIALS





4. TIF model development

Green Optics Co.,Ltd



Preston Equation: $\Delta z = \alpha PV \Delta T$ (Depth of TIF vs. Input variables)

4. Polishing tool - requirement and specification

OVT (Orthogonal	l Velocity Tool)
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ltems		Detailed items	Ranges / Spec.	
Req.	TIF shape		Gaussian shape	
	Wheel	Rotation speed	15~1000 rpm	
		Contact width	3.8 ~ 3.9 mm	
		Contact area	6.0 ~ 6.5 mm ²	
Spec.	Rotational axis (Radial direction)	Rotation speed	4~60 rpm	
-		Motion control item	Rotation angle Dwell time	
	Load cell	Measurement ranges	Min.: 0.1 psi Max.: 10 psi	
Development		KASI, SphereDyne, YoonSeul		



TIF polishing head





4. TIF generation on coupon

Input parameters

Force	Force (kgf)	0.07	0.09	0.11	
	Pressure (psi) [P]	17.27	20.10	23.33	
	Wheel rotation	Wheel rotation speed (rpm)	17	23	29
	speed	Linear rotation speed of wheel (m/sec) [V]	0.086	0.117	0.147
	Dwall time	Dwell time (sec)	5	10	15
	Dweir time	Dwell time (hour) [∆T]	0.0014	0.0028	0.0042

Generated TIF patterns







4. Preston equation and TIF comparison





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4. TIF analysis

TIF analysis

Corresponding coef. of material removal (a)

- Coorstek: 7.28 (um/(psi·hour·m/sec))
- POCO: 6.57 (um/(psi·hour·m/sec))
- SSG: 6.57 (um/(psi·hour·m/sec))



Wheel speed vs. Depth











4. TIF analysis – relationship between parameters

Preston coefficient and TIF depth







PREPARATION OF ENVIRONMENTAL TESTING





4. Preparation of environmental testing



RESULTS AND IMPLICATIONS





5. Results and Implication

- International collaboration efforts among NOAO, KASI and GO demonstrated a successful output for SiC mirrors.
- We developed a tools for the optical surface control, identified issues and discussed to improve the technology for SiC mirrors.
- Summary of results of coupons and 300 mm SiC mirrors provided by NOAO (work in progress).

		Coorstek	POCO	SSG
Coupons	Surface figure (nm rms)			12.3
	Roughness (nm rms)			0.092
300 mm	Surface figure (nm rms)	11.825	18.161	28.884
	Roughness (nm rms)	0.58 ± 0.03	0.50 ± 0.02	2.72 ± 0.46
Preston coefficient (um/(psi·hour·m/sec))		7.28	6.57	6.57
Polishing status		Polishing finished	Polishing finished	Finalizing

Present the understandable TIF patterns

Established TIF characteristic maps for various SiC mirrors





5. Results and Implication

- Preparation of environmental testing for 300 mm optics
 - Chamber and stitching setup

Preparation of Phase II planning by NOAO

- Period: 2016~2018 (3 years)
- Size: 500 mm in diameter
- Shapes: Off-axis aspheric, Convex aspheric, Concave aspheric
- Scope: Development of both polishing and material process









Thank you for

your attention



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