NIKON CORPORATION
GLASS BUSINESS UNIT

Introduction of Nikon's Large Silica Glass Plate

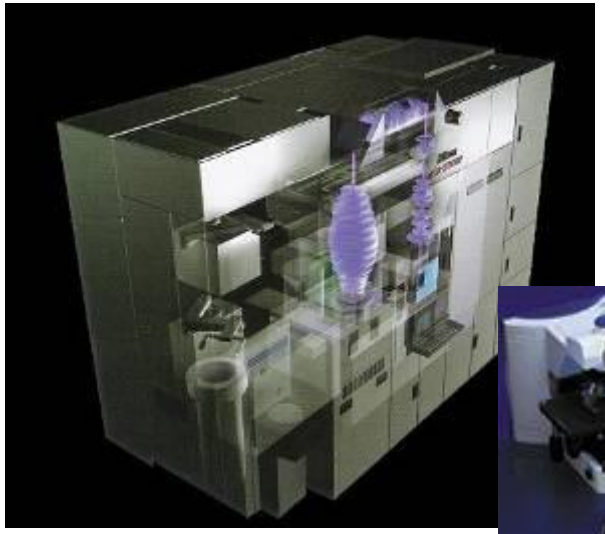
11. Nov. 2015

NGD2015-247

Precision Glass Technologies That Only Nikon Can Deliver

Nikon's Strengths

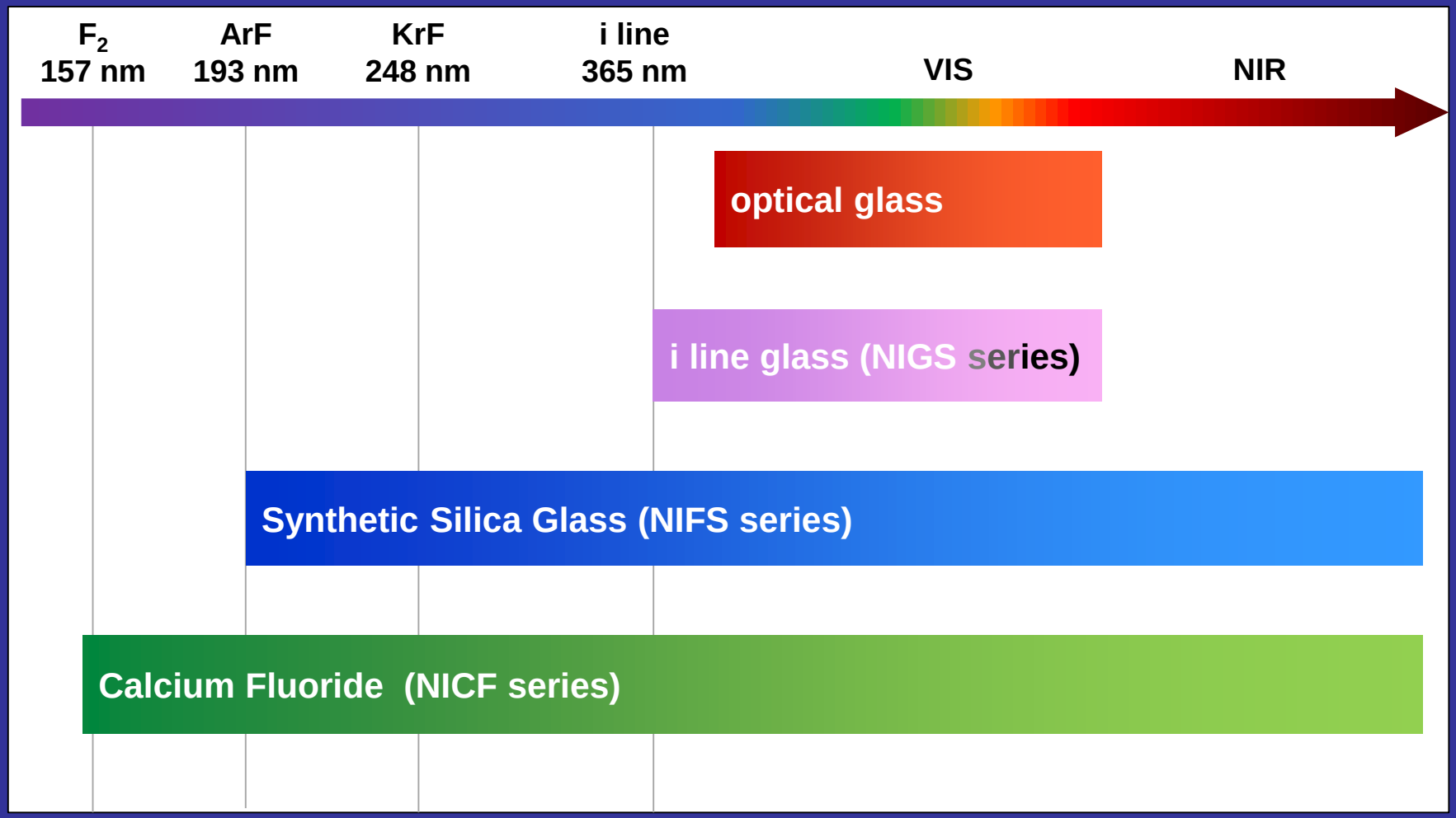
- **Integrated production from optical materials to optical products**
- **Continuous improvement driven by both internal and customer needs**



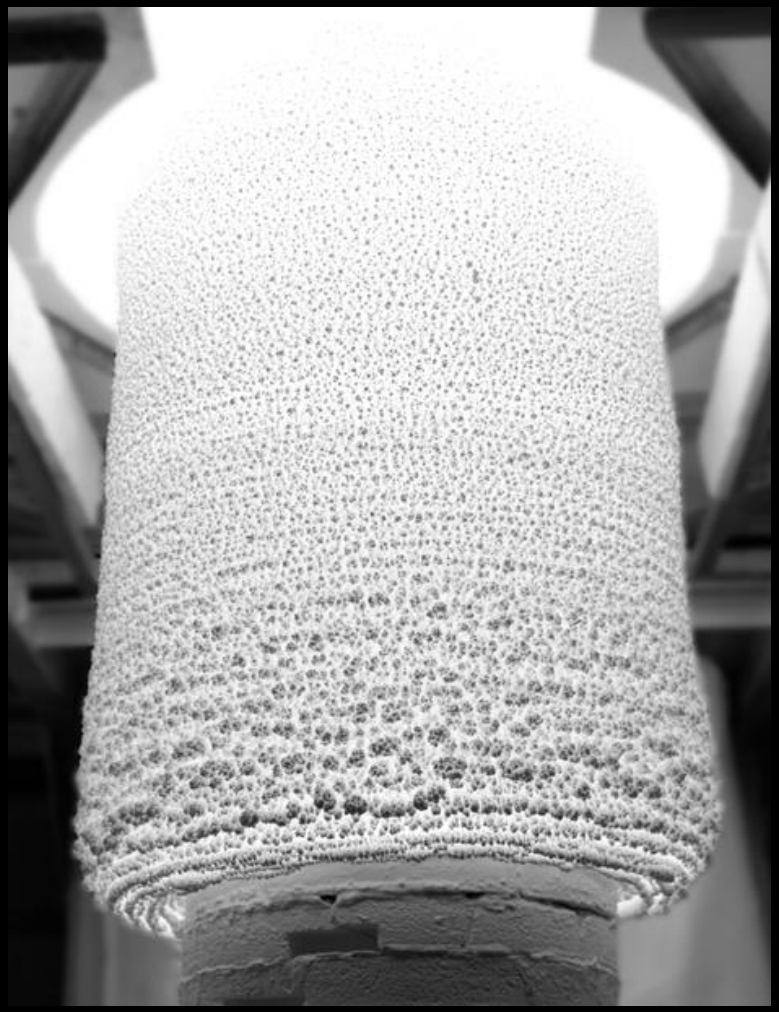
Nikon's optical material research & development goes hand in hand with the development of steppers and scanners for IC and LCD applications.

Optical Materials → **Lens** → **Optical Products**

Nikon Optical Material – line-up at wavelength –



Synthesis



World's largest ultra-pure Fused Silica ingots

Ultra-pure material synthesis:

- CVD method (frame hydrolysis)
- Quality high-purity raw materials
- Consistent manufacturing processes in controled environment

To achieve high-quality:

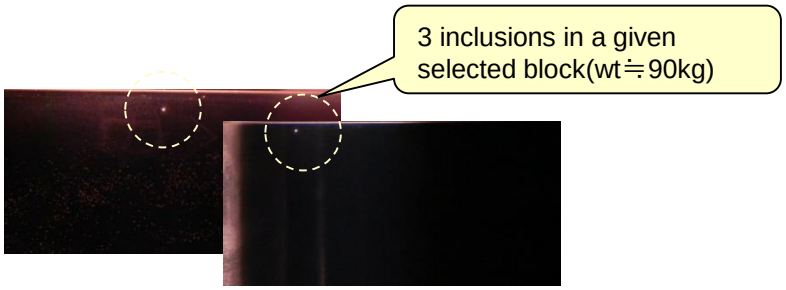
- Optimizing manufacturing condition
- Continuous feedback from high-level metrology to the manufacturing process

Features :

- Bubbles and inclusions <10um
- Maximum ingot size = φ700mm × t1000mm
- Maximum ingot weight = 1 ton
- Production capacity several dozen tons /m

Examples of inclusion inspection results

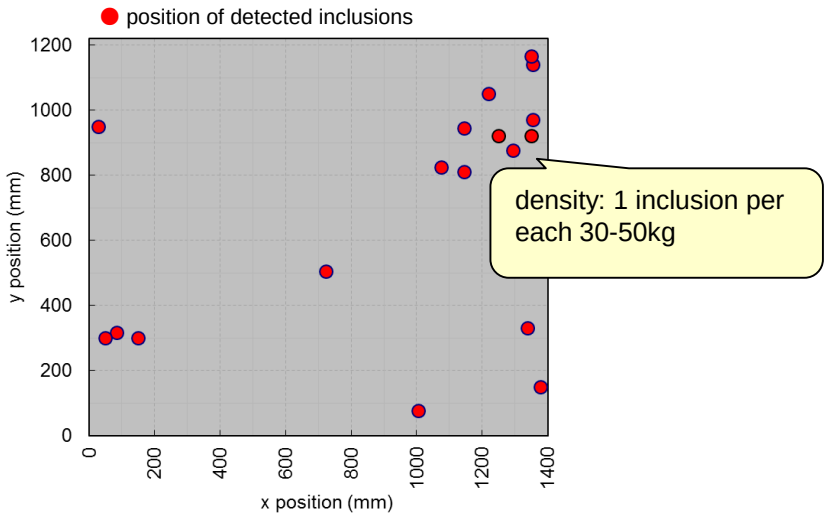
Case 1) Dark field inspection of inclusion on substrate



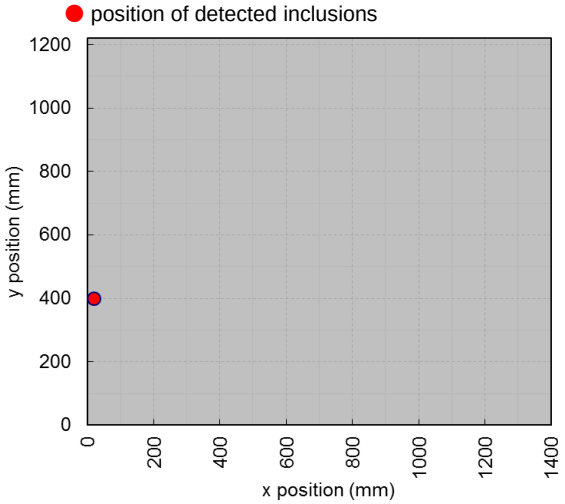
<other supplier>

<Nikon NIFS>

Case 2) LCD Photomask mother block inspection (wt≒700kg)



<other supplier>



<Nikon NIFS>

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* We show each property as representative value.

Advantages of NIFS

■ Material with very few inclusions

In Nikon fused silica (NIFS) , only one inclusion can be detected per 900kg of glass. (Figure is based on the practical inspection results of LCD mother blocks)

This feature is achieved by the optimized consistent manufacturing process.

Comparison of glass weight that one inclusion can be detected

Nikon	Supplier C
900kg	50kg

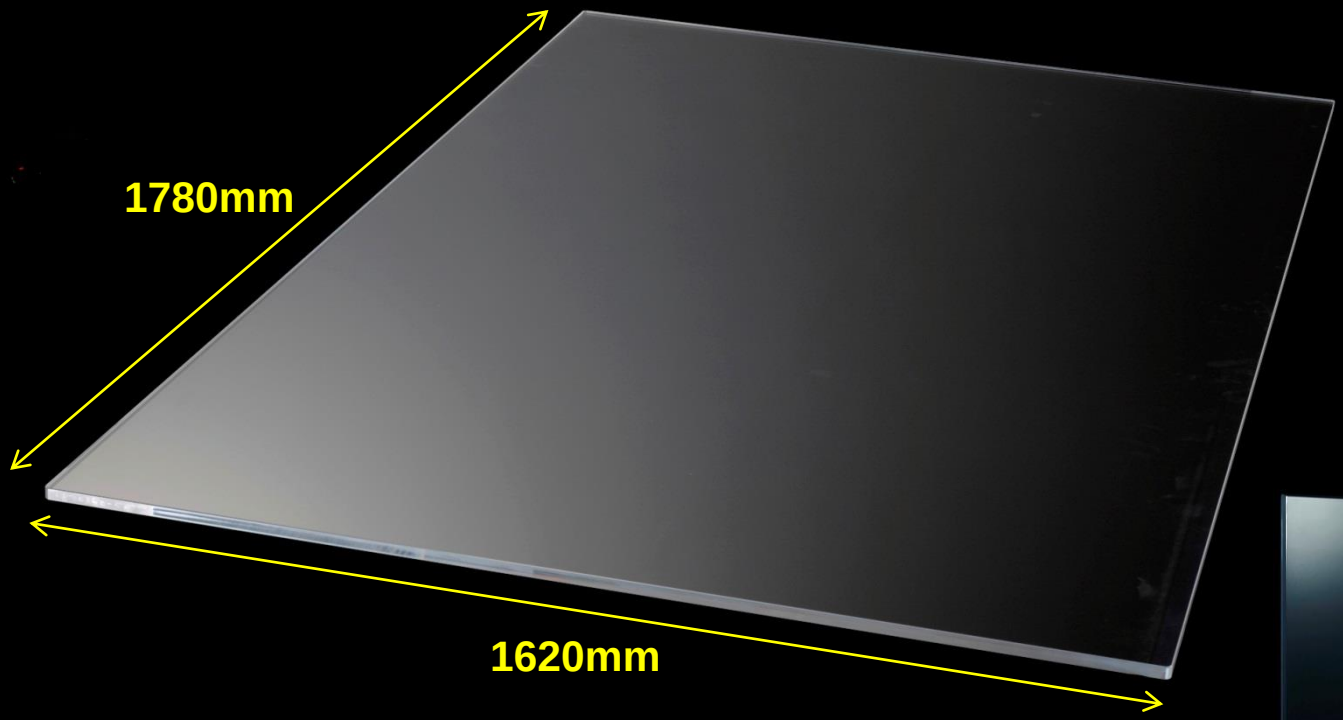
■ High sensitive inspection

Skilled inspectors and the optimized inspection environment make it possible high sensitive inspection to detect a small inclusion. Standard detection limit is 50μm @ ground surface, 2μm @ polished surface.

* We show each property as representative value.

Nikon's technology for LCD substrate

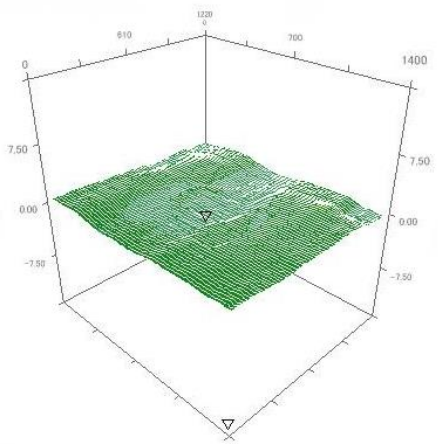
Nikon's unique technology enables production of large-generation photomask substrates.



Laeding supplier of gen.10 photo mask substrate in the world

Super Flat Mask

Nikon's *Super Flat Mask* is a high-precision FPD photomask substrate optimized for the production of next generation, high-resolution liquid crystal and AMOLED panels.



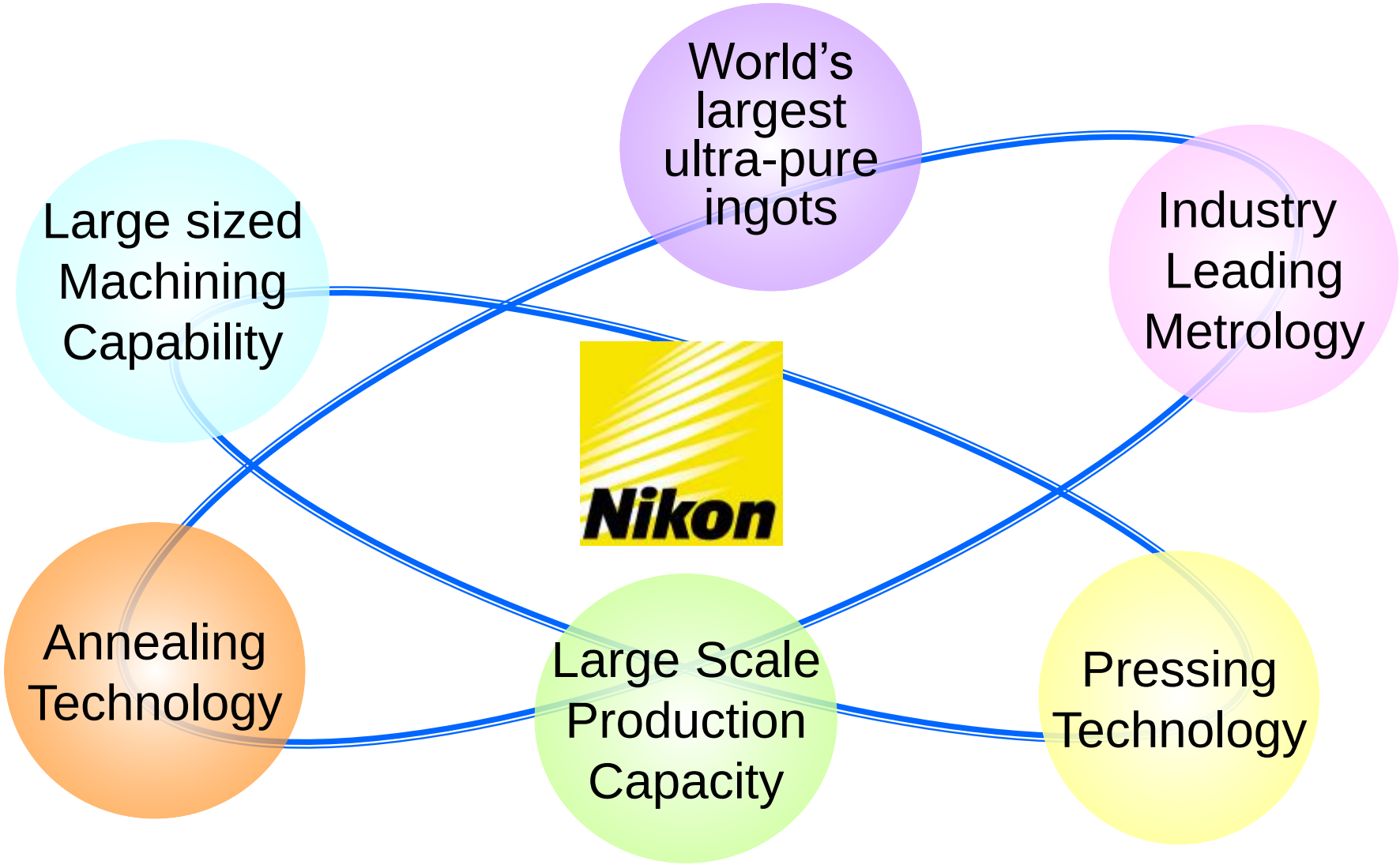
Flatness (Front) ≦5μm
Flatness (Back) ≦5μm
TTV ≦7μm

Example of Flatness measurement result

Specification

	Size (mm)		Thickness (mm)		Flatness Surface (μm)		TTV (μm)	Appearance
					Front	Back		Defect (≦1μm)
SFM	800 × 920	±0.3	10	±0.1	≦7	≦15	≦20	ND
	1220 × 1400	±0.3	13	±0.1	≦7	≦15	≦20	ND
SFM-S	800 × 920	±0.3	10	±0.1	≦5	≦5	≦7	ND
	1220 × 1400	±0.3	13	±0.1	≦5	≦5	≦7	ND

Integrated process for Large Optical Materials

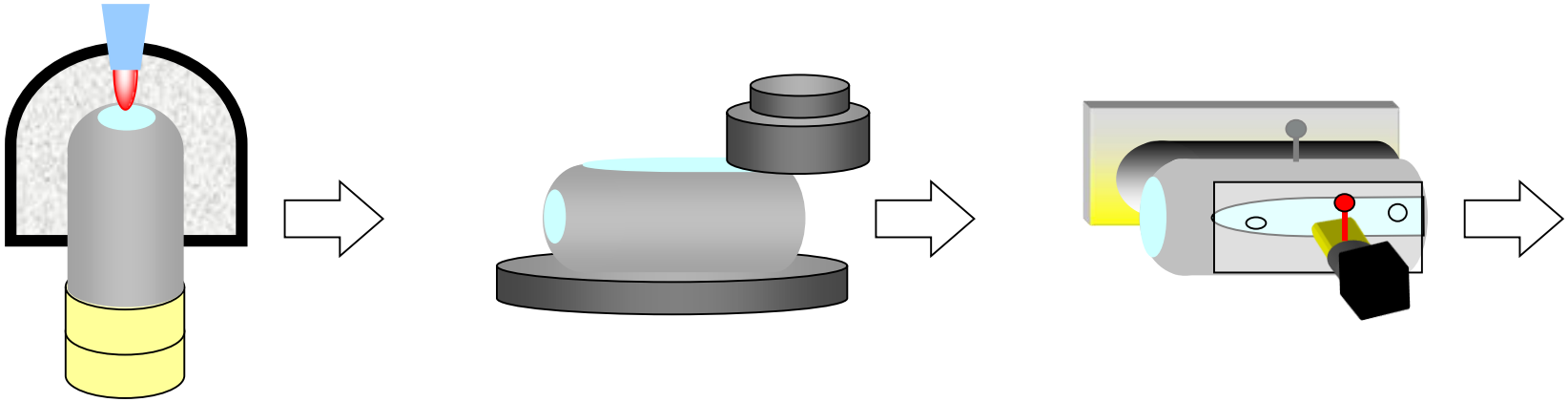


Trial fabrications of prototype Radiator for DIRC

1. Radiator disc for Endcap DIRC of PANDA
2. Radiator bar for Barrel DIRC of PANDA
3. Radiator plate for TORCH

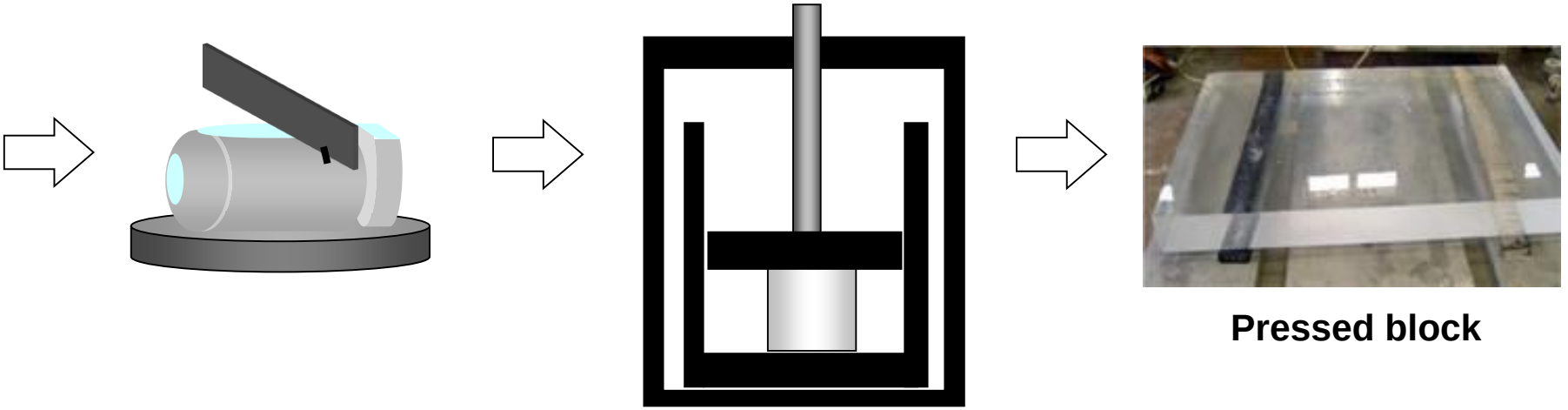
Fabrication procedure 1

Synthesis → **Grinding** → **Inspection of ingot**



Maximum weight of silica glass ingot is 1ton.

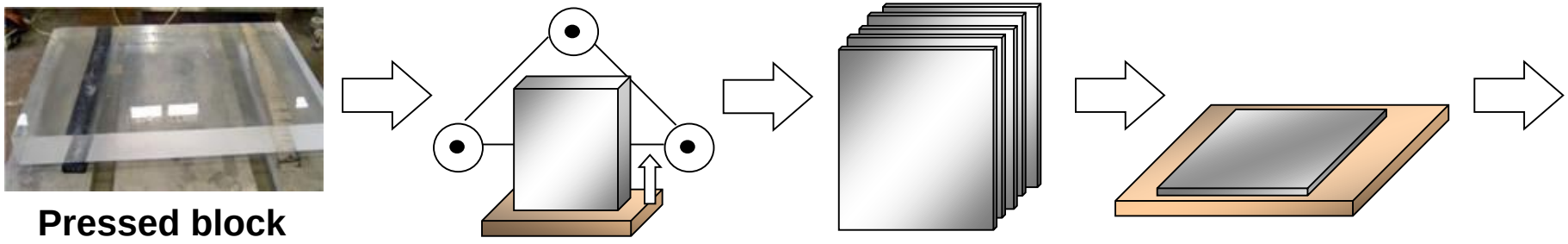
Cutting of ingot → **Pressing**



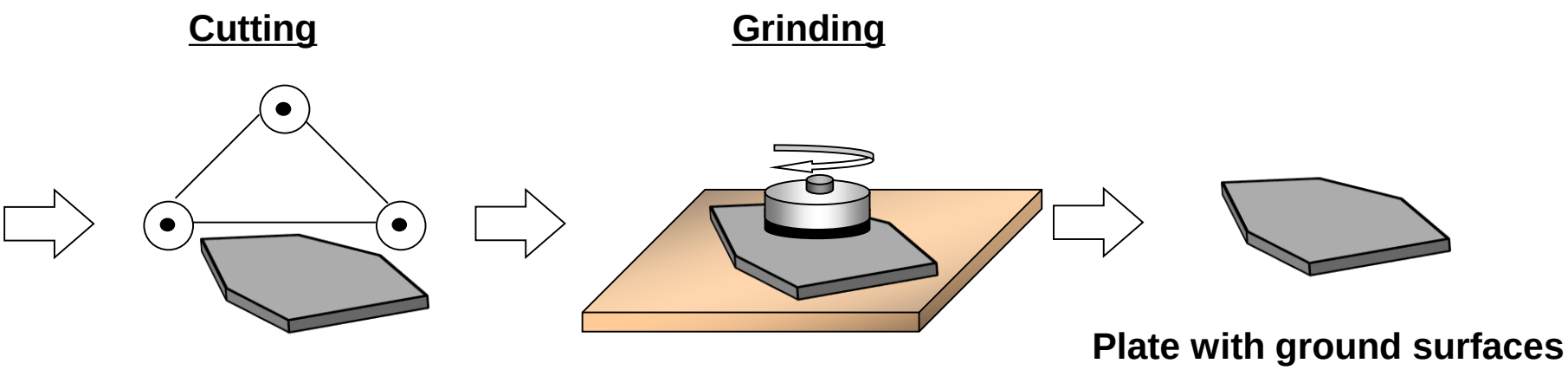
Pressed block

Nikon has pressing technique that can product □2000mm block.

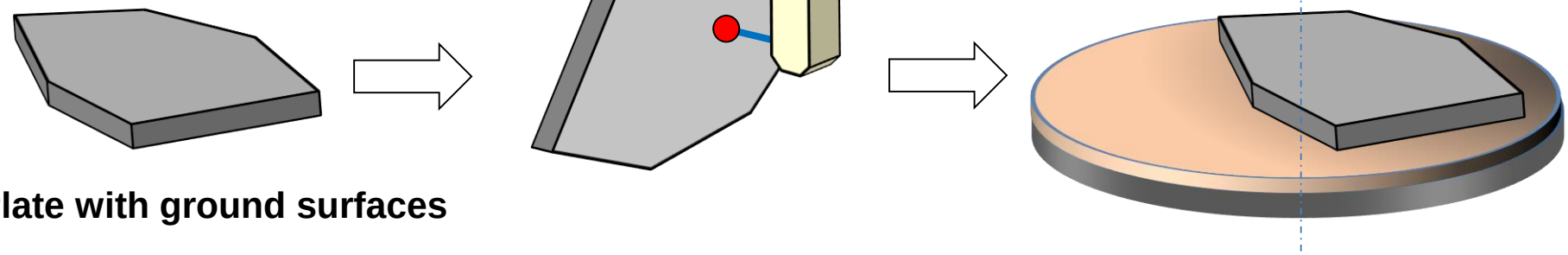
Fabrication procedure 2

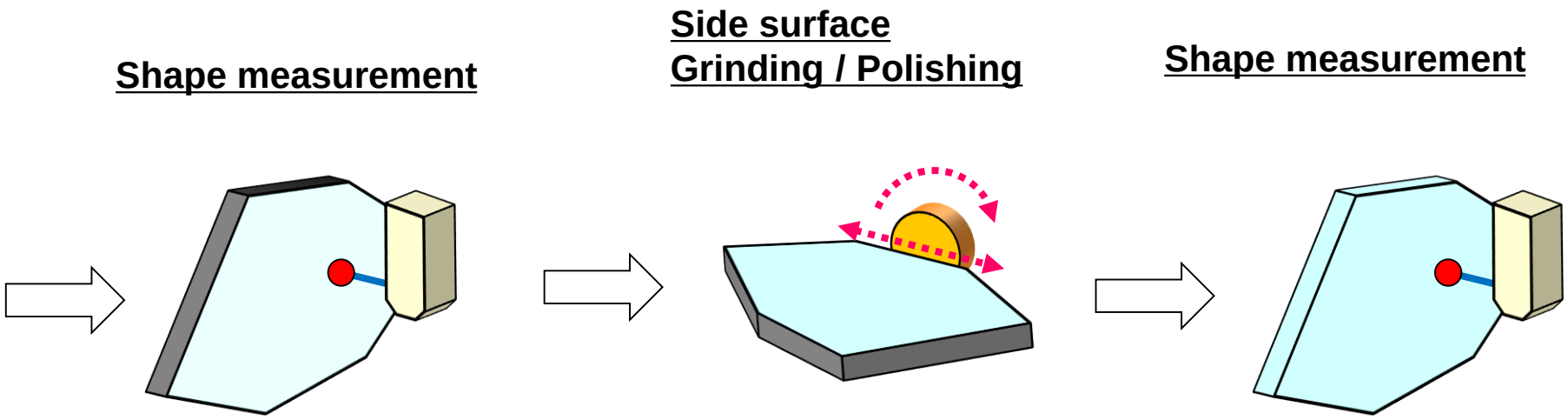


Nikon has machining equipment that can accommodate large blanks.



Fabrication procedure 3



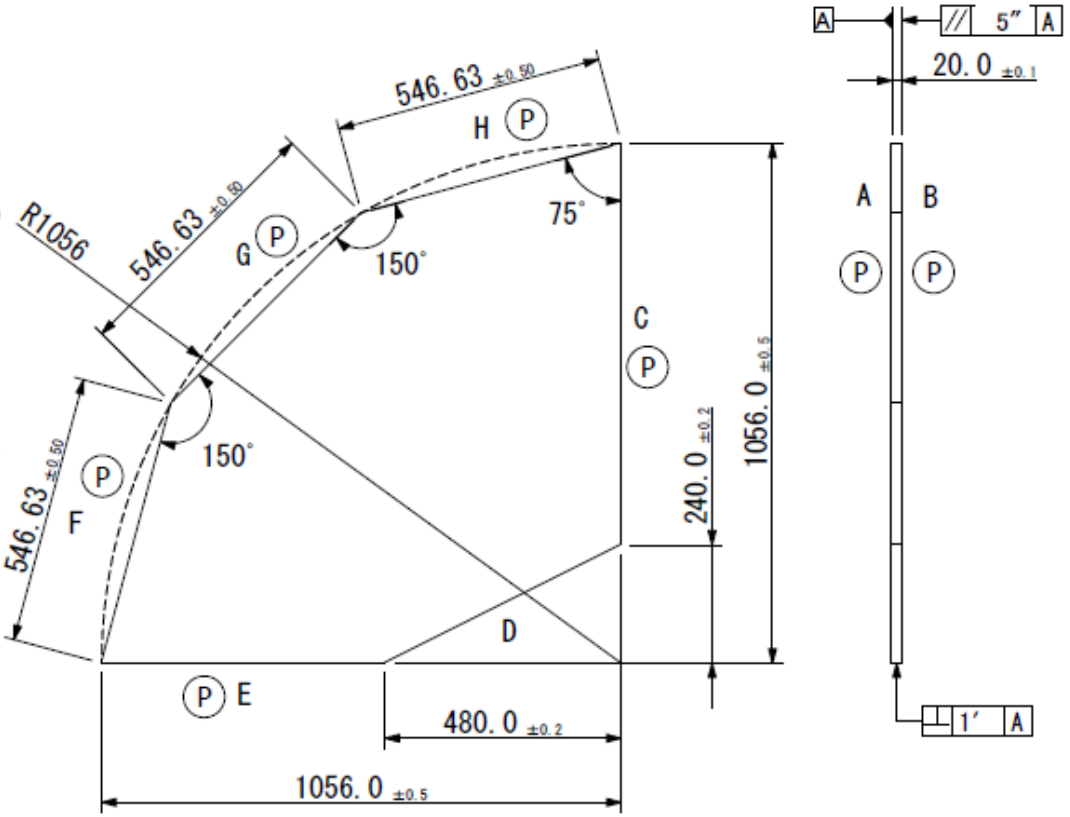


Radiator disc for Endcap DIRC of PANDA

Drawing of Prototype

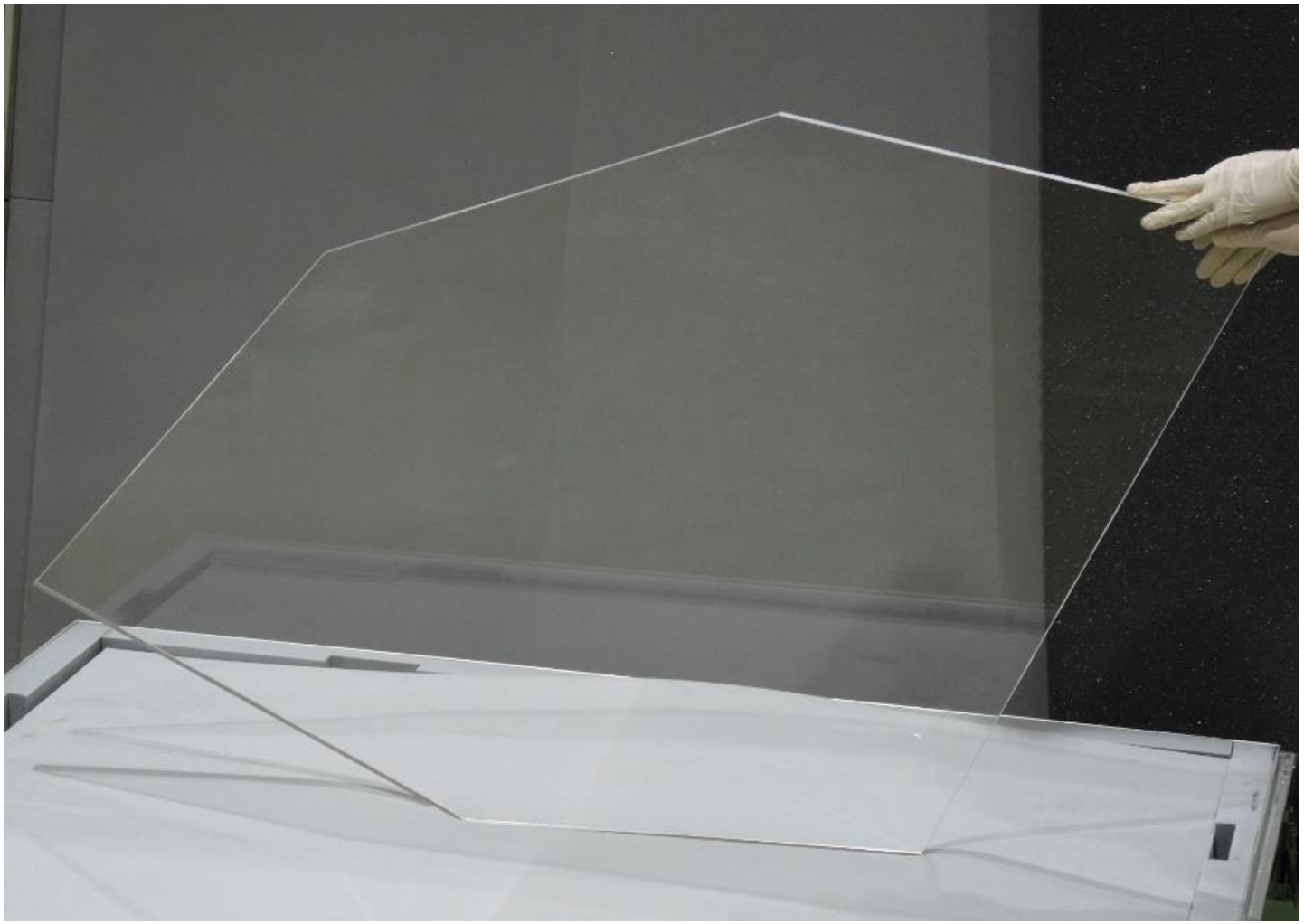
<DIMENSIONS>
- ALL DIMENSIONS IN MILLIMETERS.

<SPECIFICATION>
- SURFACES MARKED "P" ARE POLISHED.
- SURFACE D SHALL BE FINE GROUND FINISH.
- CHAMFERS : 0.5mm FOR LONG SIDES
  1.0mm FOR CORNERS
- SCRATCH/DIG : ALL SURFACES, S/D=80/50
- EDGE CHIPS : ALL SIDES, 10 CHIPS/m AND ≦1mm
- SURFACE ROUGHNESS : SURFACE A,B 1.5nm rms
  SURFACE C,E,F,G,H 5 nm rms
  SURFACE D NOT SPECIFIED
- SURFACE FIGURE (SURFACE A,B) : ≦20μm PV @WHOLE AREA
  ≦1μm PV @ANY φ10mm AREA
- SURFACE FIGURE (SURFACE C,E,F,G,H) : ≦25μm PV
- PARALLELISM : ≦5 ARCSEC
- PERPENDICULARITY : ≦1 ARCMIN
  SURFACE D NOT SPECIFIED
- CLEAR APERTURE : GO UP TO PHYSICAL EDGE OF PART



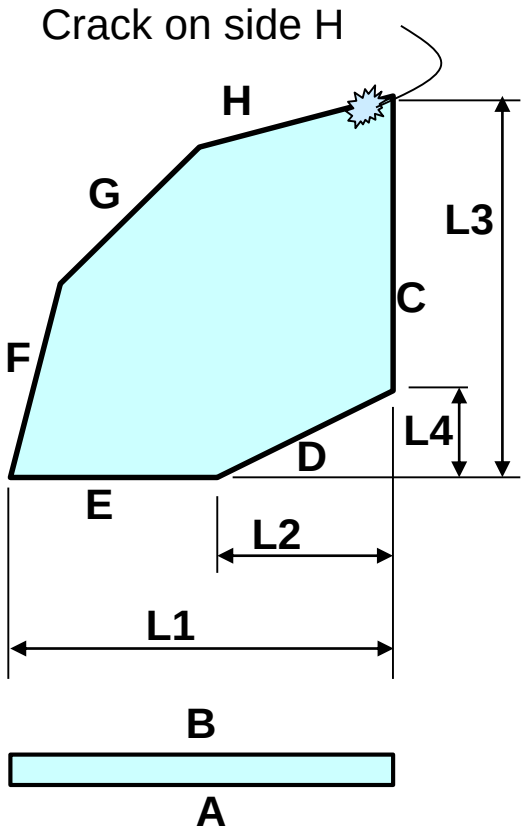
Prototype Radiator Disc for Endcap DIRC of PANDA

Picture of prototype



We completed first trial and are processing second one.

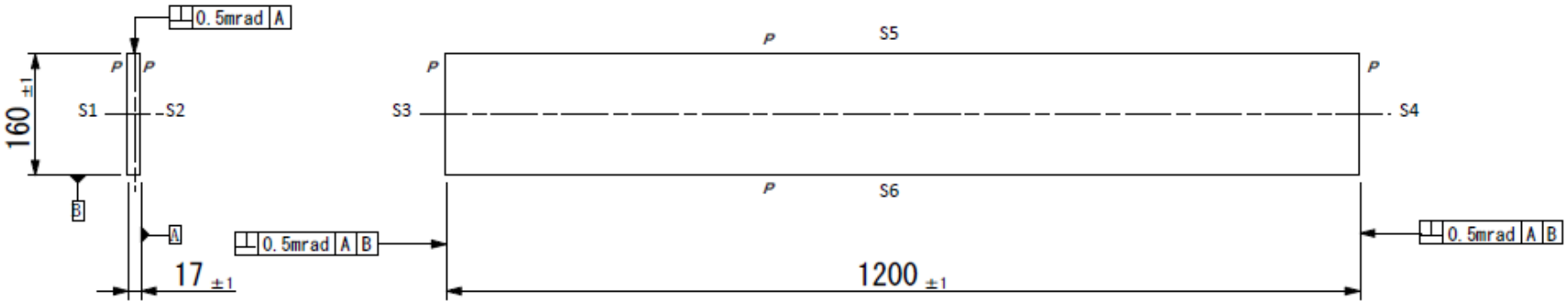
First trial results



Specification			unit	Result	
Flatness	A	20	μm	19.5	Pass
	C	25	μm	17.2	Pass
	D	25	μm	18.0	Pass
	E	25	μm	12.8	Pass
	F	25	μm	14.6	Pass
	G	25	μm	16.6	Pass
	H	25	μm	482.8	Fail
	B	20	μm	18.2	Pass
Perpendicularity	A⊥C	0:01:00	°	0:00:10	Pass
	A⊥E	0:01:00	°	0:00:28	Pass
	A⊥F	0:01:00	°	0:00:55	Pass
	A⊥G	0:01:00	°	0:00:26	Pass
	A⊥H	0:01:00	°	0:36:59	Fail
Parallelism	A//B	0:00:05	°	0:00:11	Fail
Dimension	L1	1056±0.5	mm	1056.0	Pass
	L2	480±0.2	mm	479.8	Pass
	L3	1056±0.5	mm	1056.0	Pass
	L4	240±0.2	mm	239.9	Pass
	F	546.63±0.5	mm	546.2	Pass
	G	546.63±0.5	mm	547.4	Fail
	H	546.63±0.5	mm	546.2	Pass

Radiator bar for Barrel DIRC of PANDA

Drawing of Prototype



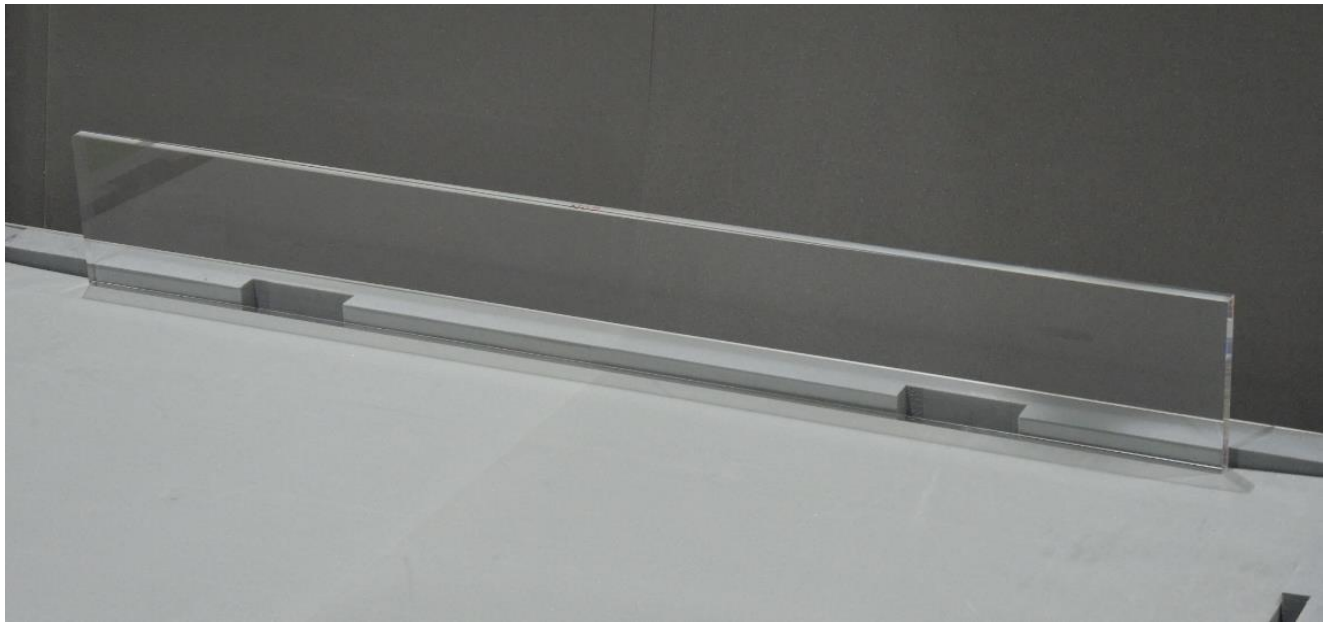
<SPECIFICATION>

・FINISHING	:	Polished	
・SURFACE ROUGHNESS	:	S3 ,S4	RMS≦2nm
		Other Surface	RMS≦1nm
・CHAMFERING	:	Sharp edge	
・SCRATCH-DIG	:	S-D=40-20	
・EDGE CHIPS	:	ALL SIDES, 10 CHIPS/m AND ≦1mm	
・TTV	:	S1-S2 ,S5-S6	<0.025mm
・PERPENDICULARITY	:	See drawing	

Prototype Radiator Bar for Barrel DIRC of PANDA

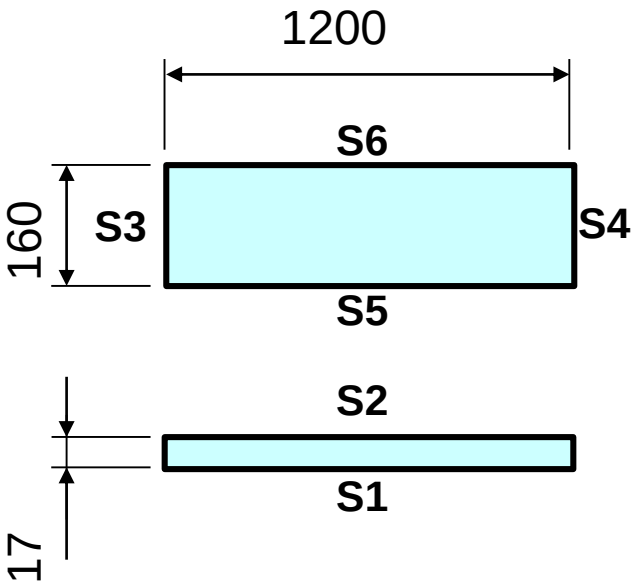
Picture of prototype

We completed first trial and are processing second one.



Sharp edges are achieved.

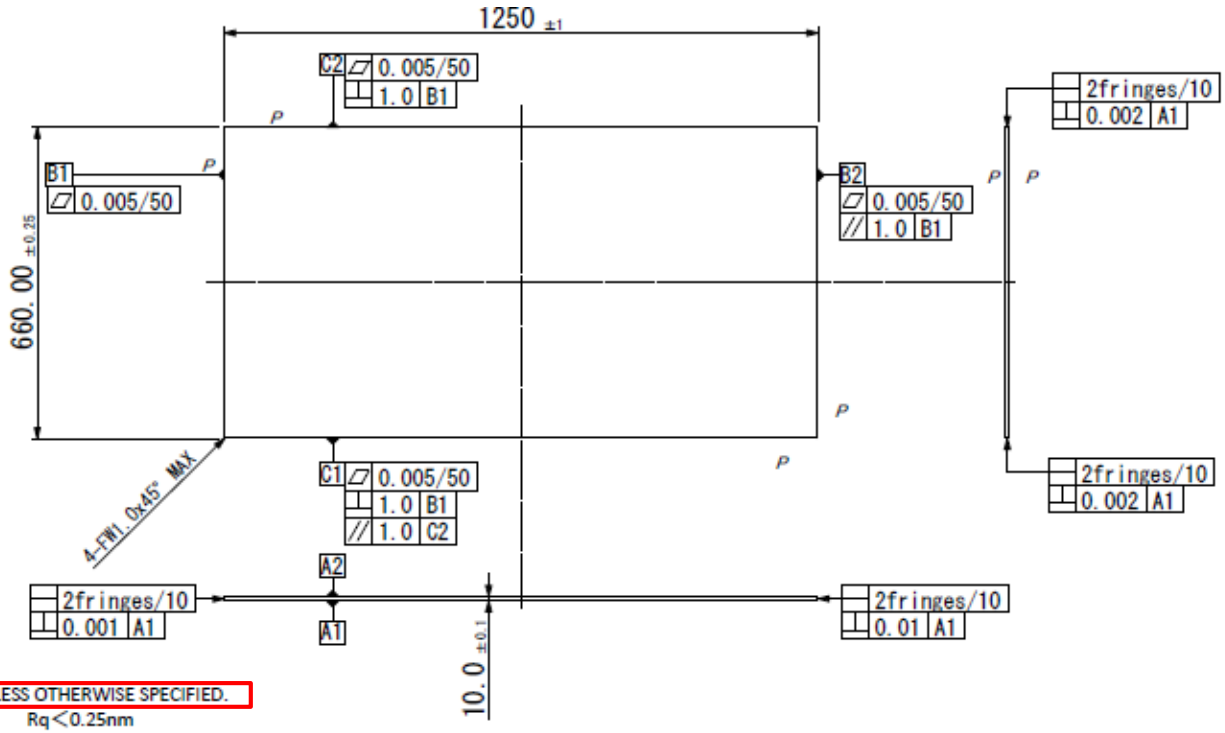
First trial results



Specification			unit	Result	
Dimension		1200±1	mm	1200.9	Pass
		160±1	mm	160.9	Pass
		17±1	mm	18.0	Pass
Perpendicularity	S1⊥S3	0.50	mrad	0.4	Pass
	S1⊥S4	0.50	mrad	0.3	Pass
	S1⊥S5	0.50	mrad	0.1	Pass
	S1⊥S6	0.50	mrad	0.1	Pass
	S6⊥S3	0.50	mrad	0.3	Pass
	S6⊥S4	0.50	mrad	0.3	Pass
TTV	S1-S2	0.025	mm	17	Pass
	S5-S6	0.025	mm	19	Pass
Surface roughness (rms)	S3,4	2	nm	1.3	Pass
	S1,2,5,6	1	nm	0.6	Pass
Edge		sharp		sharp	Pass

First trial of Radiator Plate for TORCH

Drawing of Prototype



<SPECIFICATION>

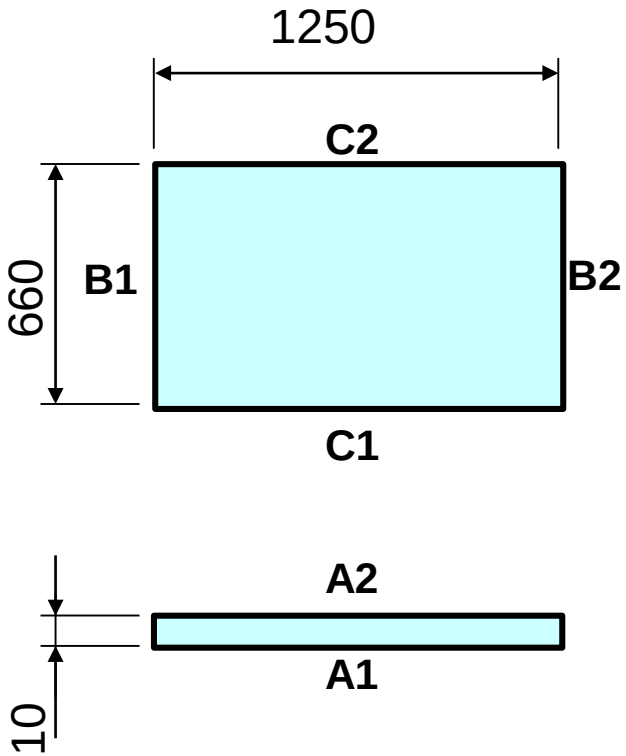
- ALL SURFACES ARE POLISHED.
- CHAMFERS : <C0.05mm, UNLESS OTHERWISE SPECIFIED.
- SURFACE ROUGHNESS : A1, A2 Rq<0.25nm
  B1, B2, C1, C2 Rq<1.5nm
- SCRATCH/DIG : 40-20 OVER THE CLEAR APERTURE SURFACES
  80-50 OUT OF THE CLEAR APERTURE
- EDGE FRACTURES : NEED TO BE GROUND OUT
- PARALLELISM : SEE DRAWING
- PERPENDICULARITY : SEE DRAWING
- FLATNESS : B1, B2, C1, C2 ≦0.005mm (AT ANY φ50mm)
- STRAIGHTNESS : B1, B2, C1, C2 ≦2 FRINGES AT 546nm (ALONG THE THICKNESS DIRECTION)
- SURFACE FIGURE : A1, A2 ≦10 FRINGES AT 546nm (AT ANY φ50mm)
- TTV : ≦2 μm OVER THE ENTIRE CLEAR APERTURE (THICKNESS DIRECTION)
- CLEAR APERATURE : A1, A2 UP TO 5mm FROM EDGES
  : B1, B2, C1, C2 UP TO 0.5mm FROM EDGES

Prototype Radiator Plate for TORCH

Picture of prototype

We are processing first trial.

First trial interim results



Specification			unit	Result	
Dimension	Long	1250±1	mm	1251.143	Fail
	Short	660±0.25	mm	661.100	Fail
	Thickness	10±1	mm	10.056	Pass
Parallelism	B1//B2	1.0	mm	0.1	Pass
	C1//C2	1.0	mm	0.4	Pass
Perpendicularity	A1⊥B1	0.001	mm	0.001	Pass
	A1⊥B2	0.001	mm	0.001	Pass
	A1⊥C1	0.002	mm	0.001	Pass
	A1⊥C2	0.002	mm	0.001	Pass
	B1⊥C1	1.0	mm	0	Pass
	B1⊥C2	1.0	mm	0	Pass
Straightness (along the thickness direction)	B1、B2、C1,C2	2	Fringes at 546nm	20	Fail
Flatness (at any φ50mm)	A1	10	Fringes at 546nm	3	Pass
	A2	10	Fringes at 546nm	2	Pass
	B1、B2、C1,C2	0.005	mm	0.006	Fail
TTV	A1-A2	2	μm	2	Pass
Scratch-Dig	A1,2	40-20		○	Pass
	B1,B2,C1,C2	80-50		○	Pass
Surface roughness (rms)	A1,2	0.25	nm	0.24	Pass
	B1,B2,C1,C2	1.5	nm	1.3	Pass
Chamfer		C0.05	mm	sharp	Pass

Nikon has the capability of producing Radiator for DIRC.

Nikon's advantages are below.

- **Material quality**
- **Large processing capability**
- **Polished surface quality**
- **Integrated production from optical materials to optical products**

Thank you for your attention
Vielen Dank für Ihre Aufmerksamkeit
Domo arigato gozaimasu

NIKON CORPORATION