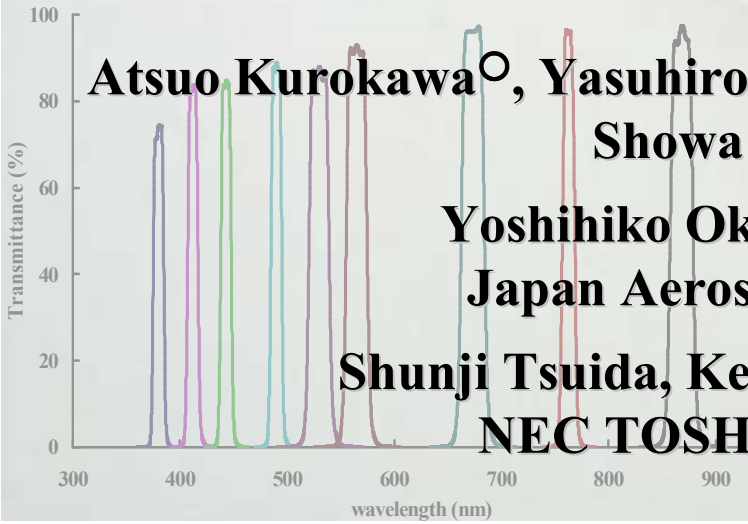
Showa Optronics Co., Ltd.

High-precision narrow-band optical filters for global observation



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Outline

◎Back Ground

- Optical Filters on GCOM-C1 Satellite
- Specification and Important Factor for VN Filters
- Benefits of High-Precision Band Pass Filter

◎Preliminary Study of Manufacturing Filters

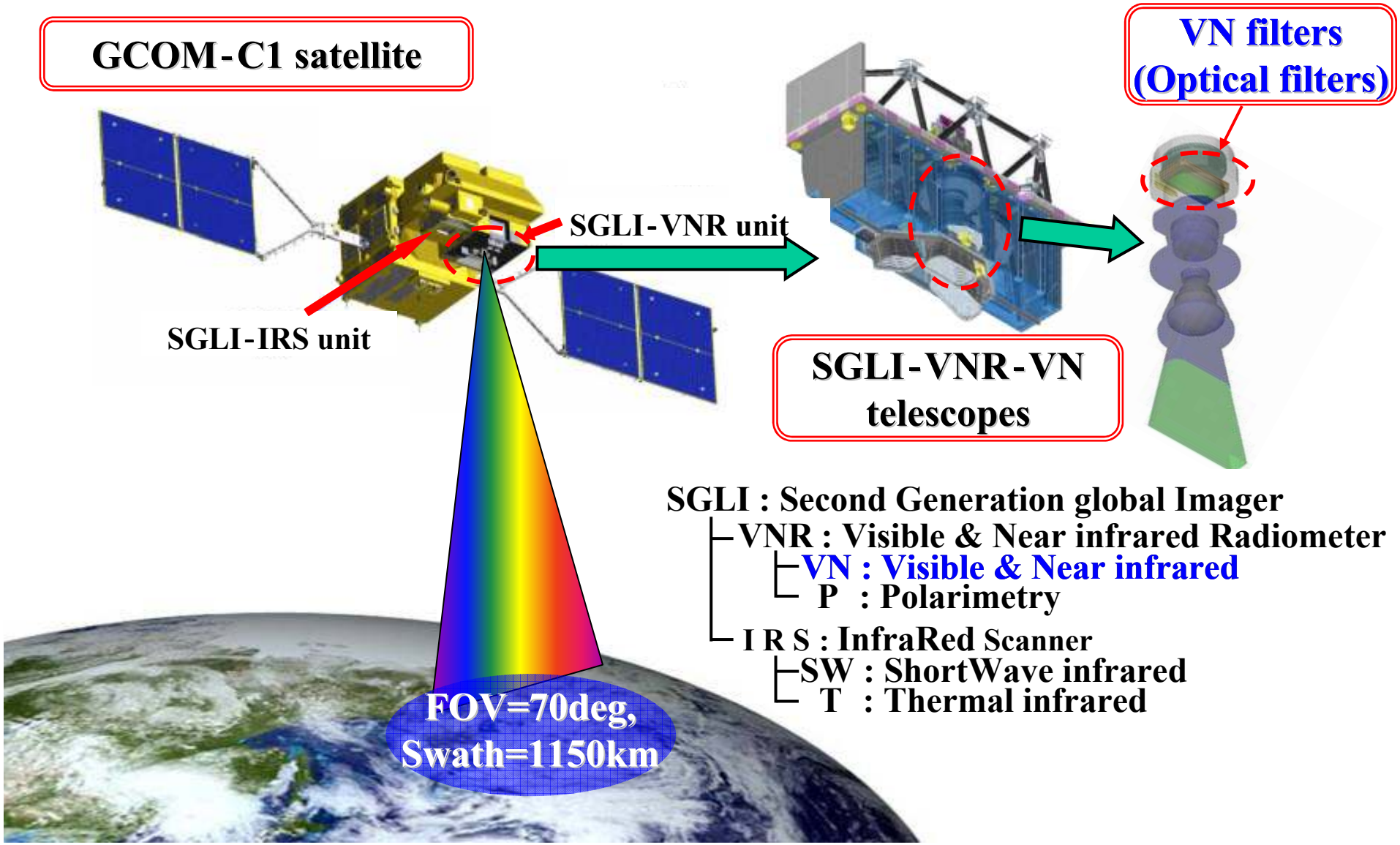
- Coating Methods
- Film Thickness Distribution and Coating Equipments
- Error of Center Wavelength (CWL) Uniformity

◎Results and Discussion

- CWL Error & Error of CWL Uniformity
- Spectrum Shift Caused By Telecentric Error
- Controlling CWL Distribution

◎Summary

Optical Filters on GCOM-C1 satellite



SGLI : Second Generation global Imager
- VNR : Visible & Near infrared Radiometer
  - VN : Visible & Near infrared
  - P : Polarimetry
- I R S : InfraRed Scanner
  - SW : ShortWave infrared
  - T : Thermal infrared

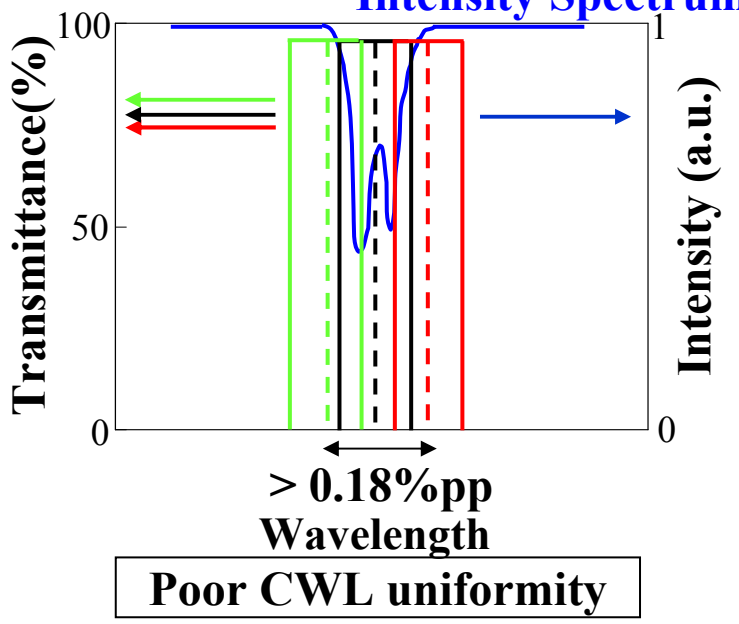
Specification and Important Factor for VN Filters

Table. Main Specifications for pass band characteristics of VN filters

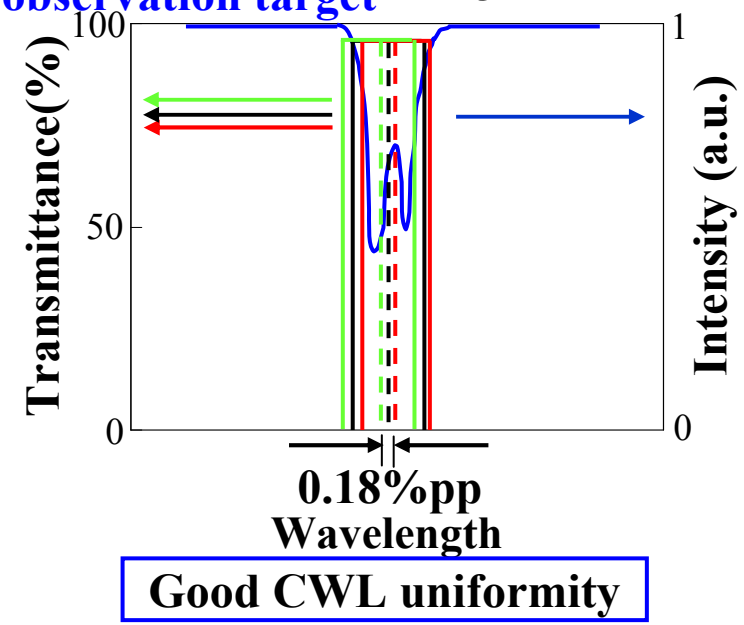
		unit	VN1	VN2	VN3	VN4	VN5	VN6	VN7,8	VN9	VN10,11
Center Wavelength (CWL)	Nominal value	nm	380.0	412.0	443.0	490.0	530.0	565.0	673.5	763.0	868.5
	Tolerance	nm	±1.5	±1.6	±0.9	±1.0	±1.1	±2.3	±1.3	±1.5	±1.7
		%	±0.4	±0.4	±0.2	±0.2	±0.2	±0.4	±0.2	±0.2	±0.2
	Uniformity	nmPP	0.7	0.7	1.1	1.2	1.3	1.0	1.6	1.4	2.1
		%PP	0.18	0.18	0.24	0.24	0.24	0.18	0.24	0.18	0.24
Band width	FWHM	nm	10	10	10	10	20	20	20	12	20
	Tolerance	nm	±1.0	±1.0	±1.0	±1.0	±2.0	±2.0	±2.0	±1.0	±2.0

← Actual size of filters : 82mm × 1mm

Intensity Spectrum of an observation target



Poor CWL uniformity



Good CWL uniformity

Benefits of High-Precision Band Pass Filter

- High-accurate Center Wavelength
- Optimized transmission band width
  → High signal-to-noise ratio

→ Enable high-precision monitoring
Increase accuracy of environmental change prediction

- Good Uniformity over the entire effective area of substrate
  → increases filter size for large line sensors
    → reduces the number of telescope maintaining FOV
      → saves weight of satellite

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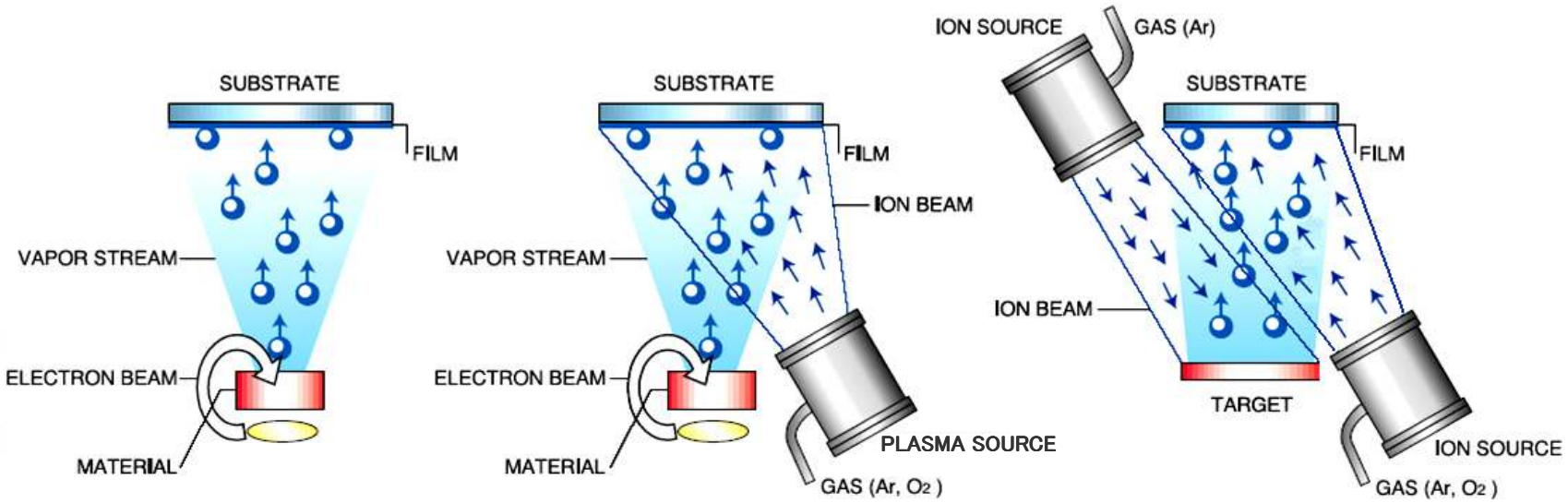
Coating Methods



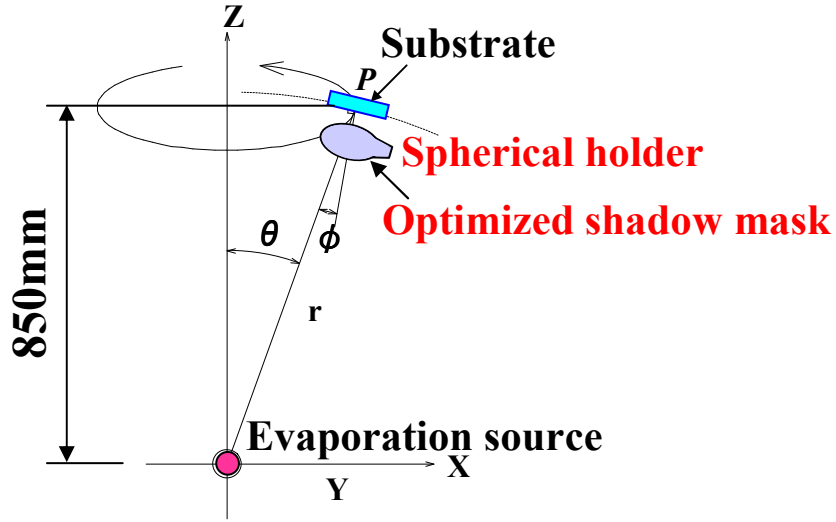
Electron Beam Physical Vapor Deposition (EB)

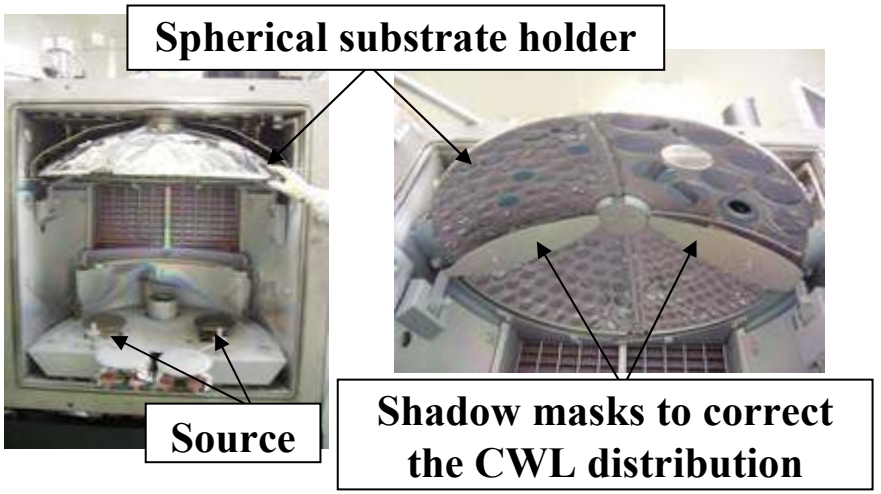
Plasma Ion Assisted Deposition (PIAD)

Dual Ion Beam Sputtering Deposition (IBSD)

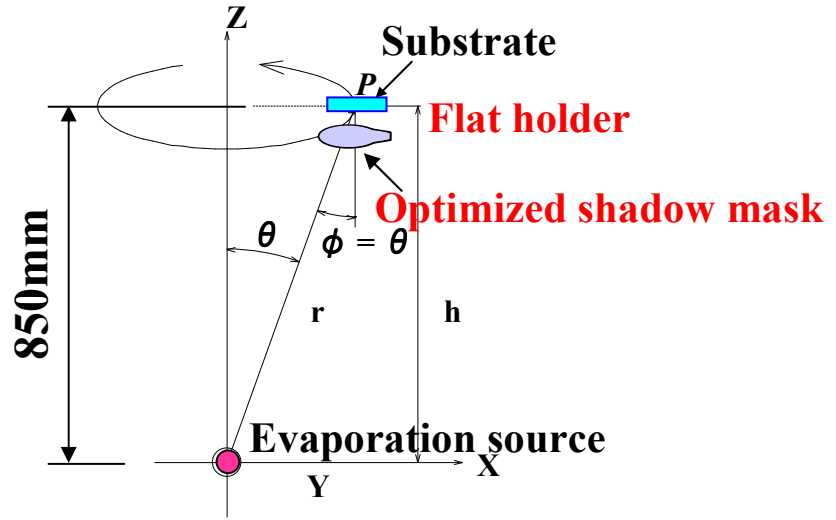
	EB	PIAD	IBSD
Packing density	Low	High	High
Spectral shift	Significant	Negligible	Negligible
Internal stress	< 100MPa	250MPa	> 350MPa
Productivity	High	High	Low

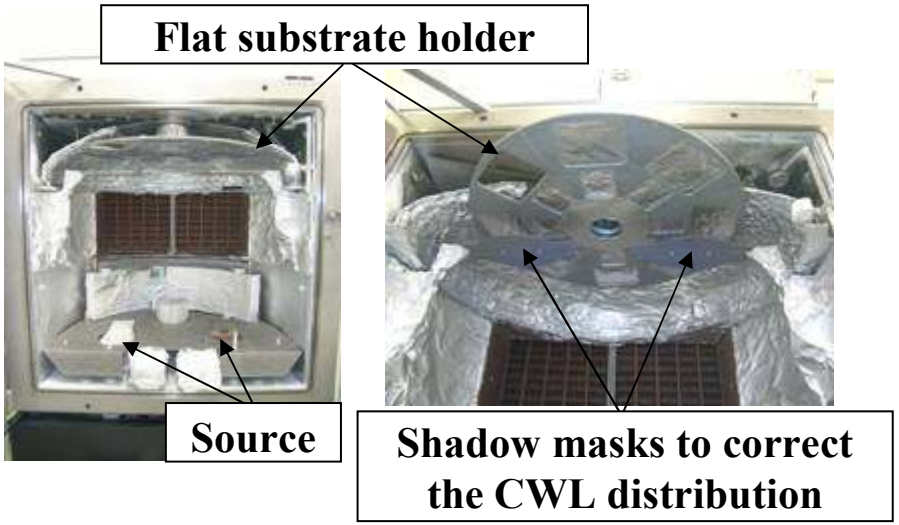
Film Thickness Distribution and Coating Equipments





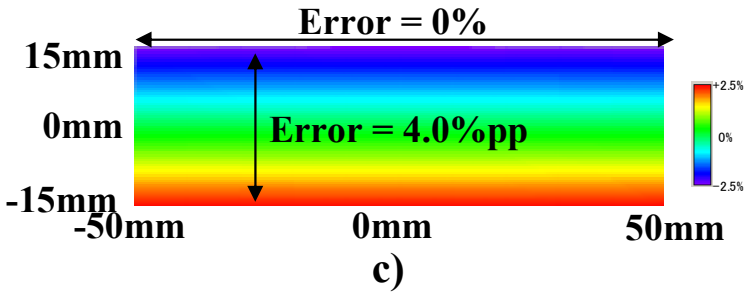
a) The geometry diagram and pictures of the spherical holder with a shadow mask



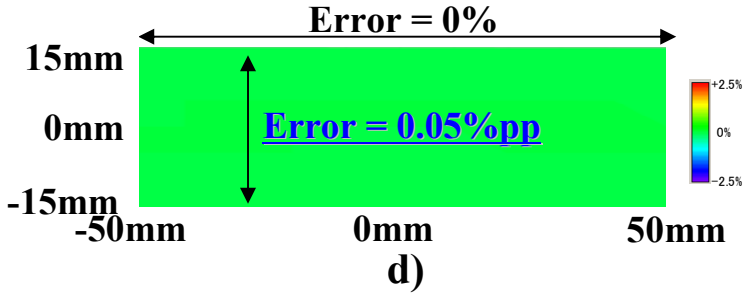


b) The geometry diagram and pictures of the flat holder with a shadow mask

Error of CWL Uniformity



c) Spherical holder with a shadow mask



d) Flat holder with a shadow mask

3 telescopes were required almost similar performance
→ 3 filters that have almost similar spectral characteristics are essential

- **High-accurate CWL**
- **Optimized transmission band width**
- **Good CWL uniformity over the entire area of the substrate**

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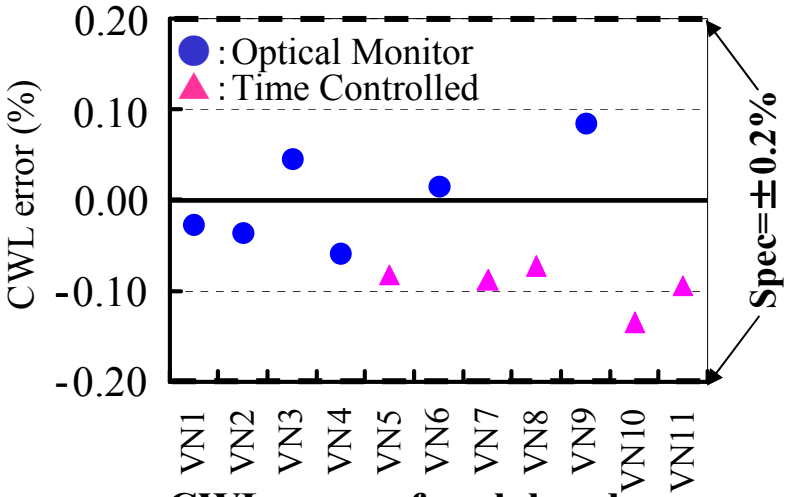
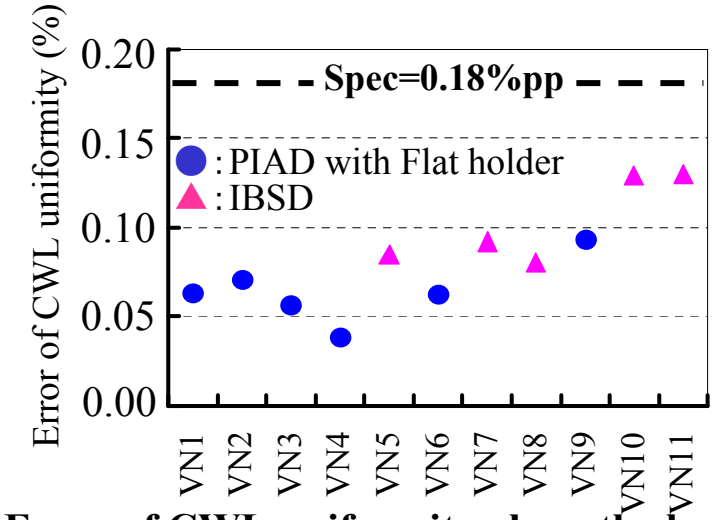
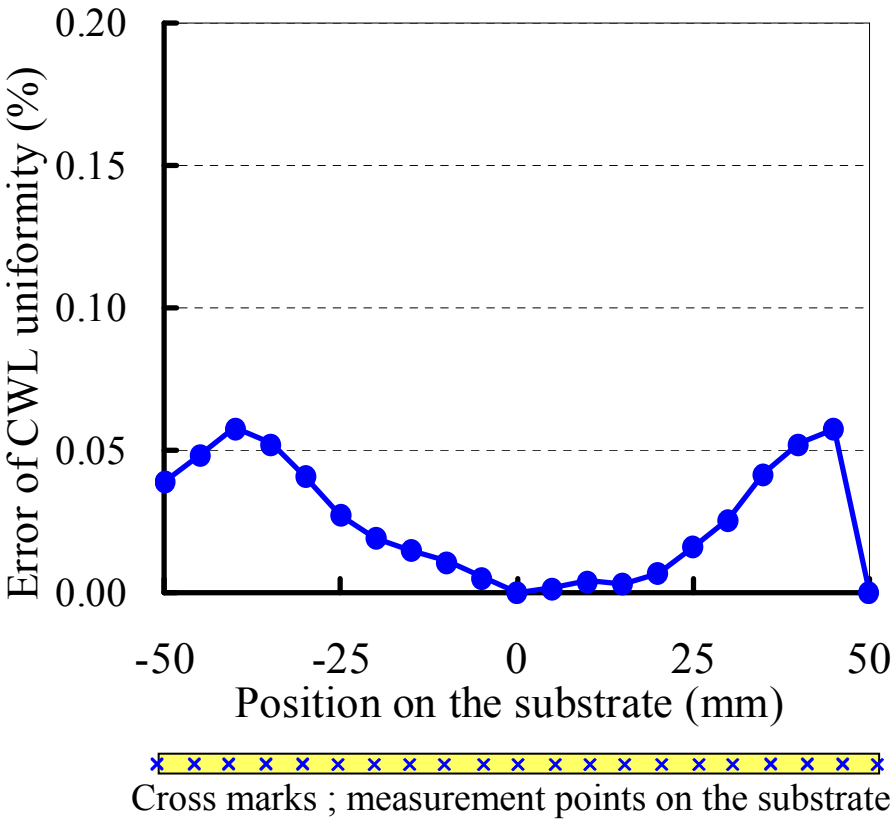
CWL Error & Error of CWL Uniformity



CWL error of each band (measurement at center of a substrate)

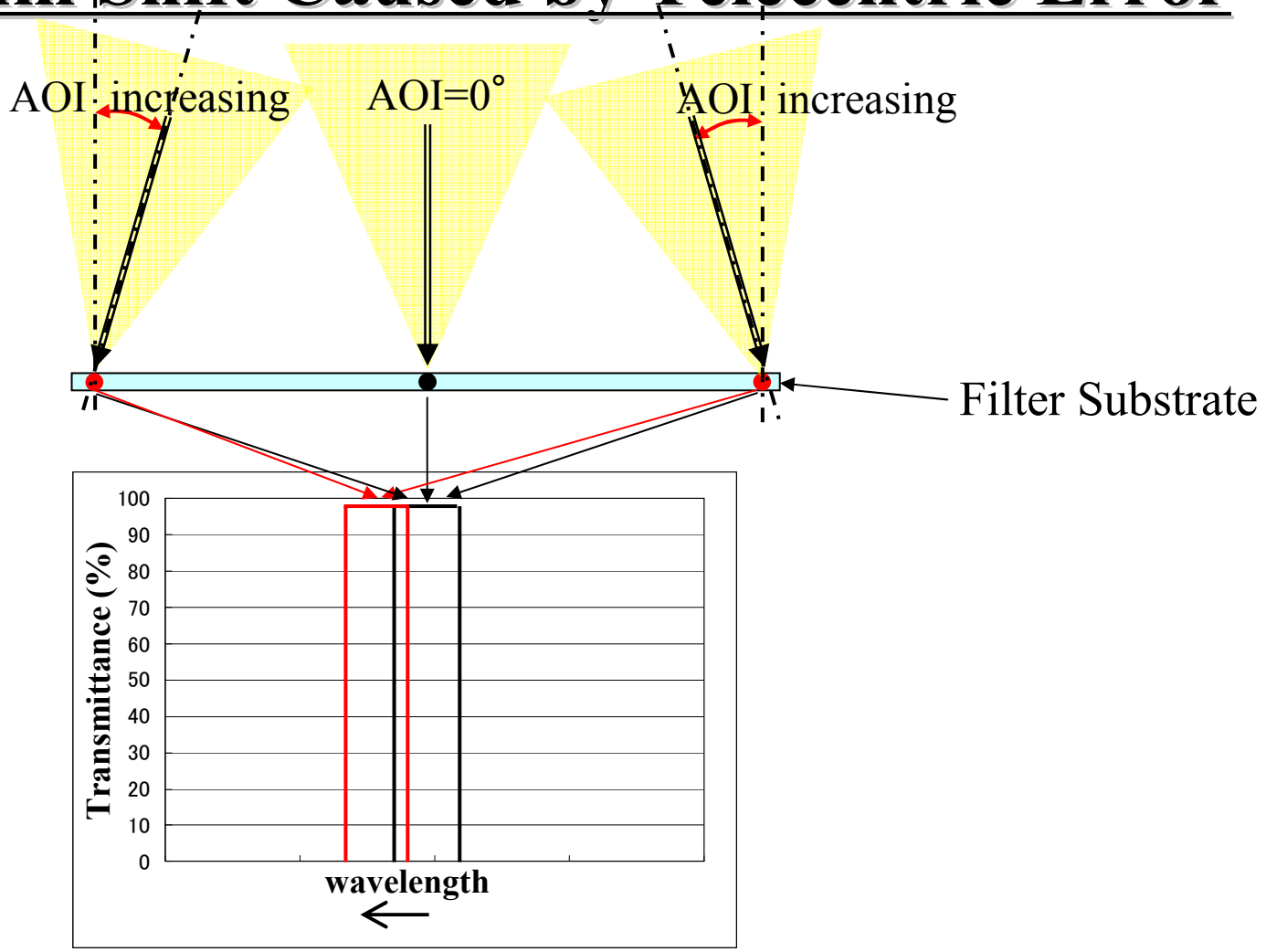


Error of CWL uniformity along the longer direction of each band (area of 82mm × 1mm)



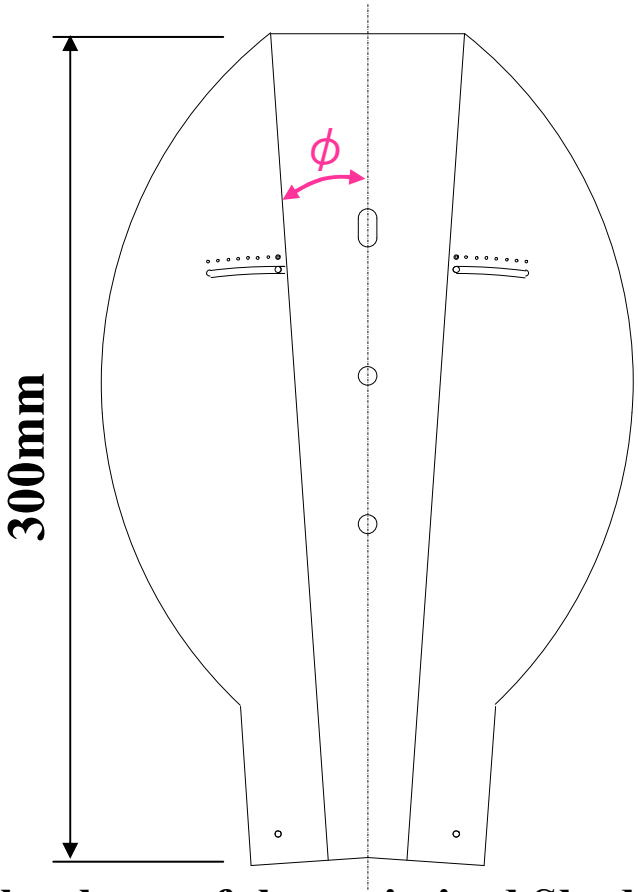
CWL distribution along the length of the VN1 filter (area of 100mm × 1mm)

Spectrum Shift Caused by Telecentric Error

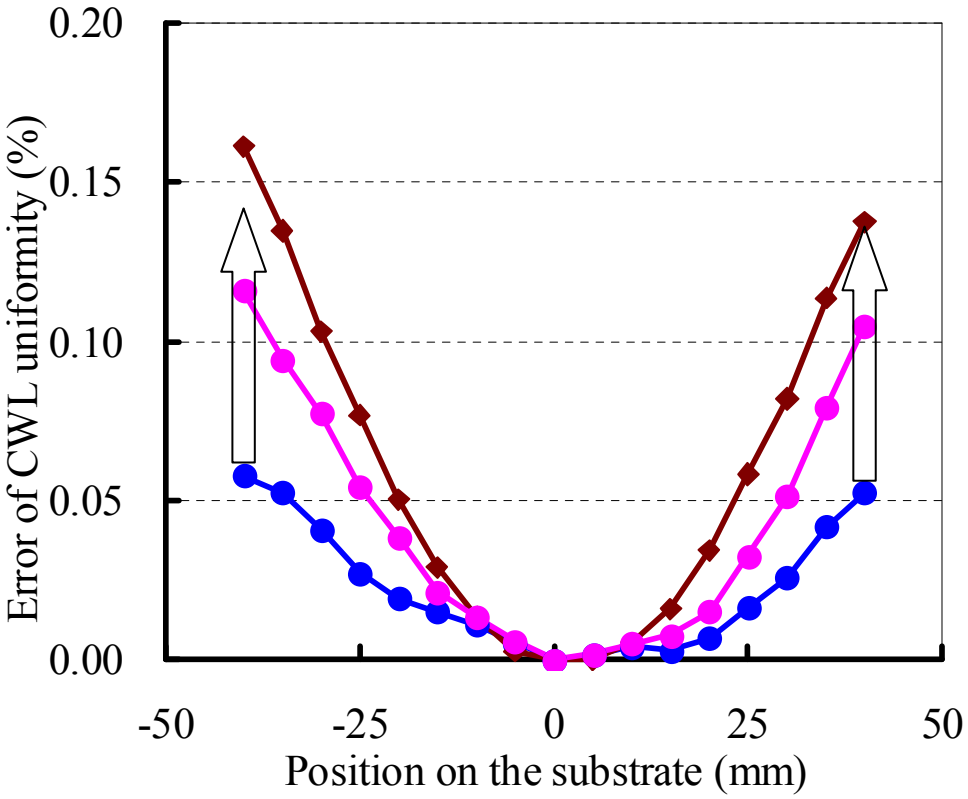


The wavelength spectrum shifts to shorter wavelength

Controlling CWL Distribution



The shape of the optimized Shadow mask



Control of CWL distribution

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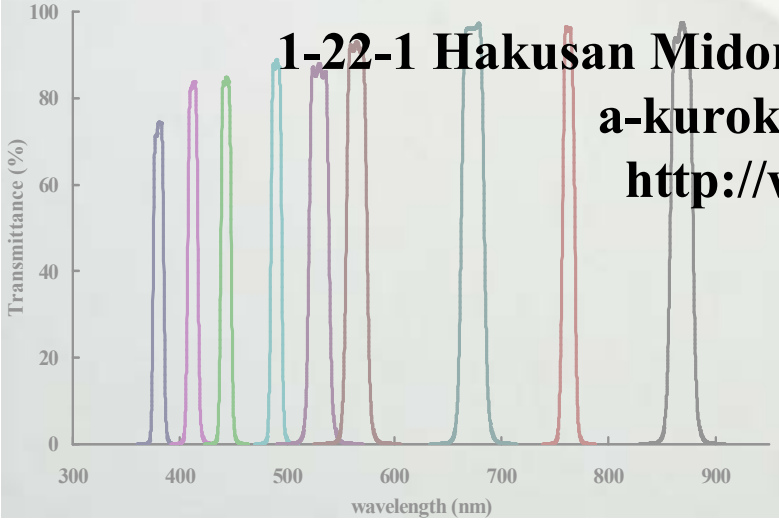
Narrow-band optical filters with

- **CWL error of better than ±0.1%**
- **CWL uniformity of better than 0.1%pp**

over an area of 100 mm × 1 mm were achieved

The possibility of compensating a spectrum shift due to a telecentric error of optical lens by controlling CWL distribution was demonstrated

Thank you for your time



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