

APPENDIXES

Nonlinear Photonic Crystal Fiber – SC-5.0-1040

Description

This single-mode nonlinear photonic crystal fiber combines a high nonlinear coefficient with zero dispersion around 1040 nm to allow efficient nonlinear interactions using 1060 nm range lasers.

The fiber is designed to convert passively Q-switched Nd³⁺-microchip lasers into a compact, low-cost, ultra-bright supercontinuum source.

Due to the optimized dispersion profile, a length of only 20 m of these fibers is sufficient to achieve near-unity conversion efficiency in combination with a laser that delivers pulses of ~1 ns, 5-10 kHz repetition rate and a few tens of milliwatts of average power at 1064 nm wavelength.

The fiber is available spliced to standard single mode fiber or endlessly single mode fiber, and is also available with hermetically sealed ends and FC/PC connectors.

An application note for using this fiber for supercontinuum is available from our website:
www.crystal-fibre.com/support/application_notes.shtm

Optical Properties

Zero dispersion wavelength:	1040 ± 10 nm
Cut-off wavelength:	< 1000 nm
Nonlinear coefficient @ 1060 nm:	11 (W·km) ⁻¹
Attenuation @ 1040nm:	< 2 dB/km
Attenuation @ 1550 nm :	< 1.5 dB/km
Attenuation @ 600 nm:	< 15 dB/km
Mode Field Diameter:	4.0 ± 0.2 μm
NA @ 1060 nm:	0.20 ± 0.05

Physical Properties

Material:	Pure silica
Cladding diameter:	125 ± 3 μm
Coating diameter:	244 ± 10 μm
Coating material:	Acrylate
Core diameter:	4.8 ± 0.2 μm

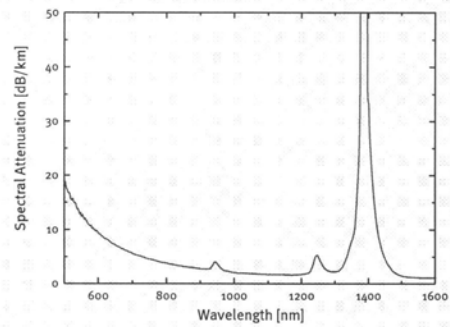
Advantages

- Small mode field area
- Zero dispersion wavelength optimized for 1060 nm wavelength pumping
- Bending insensitive
- Single mode

Applications

- Continuum generation for metrology, spectroscopy and optical coherence tomography, OCT
- Four-wave mixing
- Raman amplification
- Optical parametric amplification, OPA

Typical Spectral Attenuation



Typical Measured Dispersion

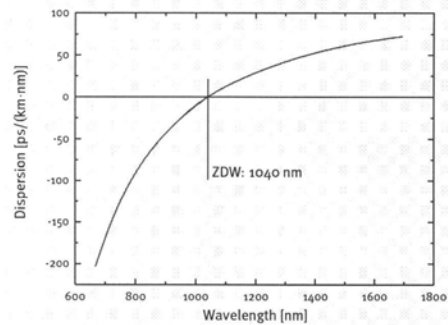


Table 1-1 lists the AQ4321 system specifications.

Table 1-1: AQ4321 specifications (1 of 4)

Model		AQ4321A	Note
Wavelength changeable width		1480 to 1580nm	
Wavelength resolution		0.001nm	
Absolute wavelength accuracy		$\leq \pm 0.015\text{nm}$ ($\pm 0.01\text{nm}$ [typ])	Note 1, Note 2, Note 3
		$\leq \pm 0.01\text{nm}$	Note 2, Note 3, Note 4
Relative wavelength accuracy		$\leq \pm 0.01\text{nm}$ [typ]	Note 1, Note 2, Note 3
Wavelength stability		$\pm 100\text{MHz/h}$ ($\pm 0.5\text{pm/h}$) [typ]	Note 3
Width of spectrum line	When NARROW is set	200MHz [typ] ($\leq 1\text{MHz}$)	Note 2
	When WIDE is set	$\geq 100\text{MHz}$, 200MHz [typ]	
SMSR		$\geq 50\text{dB}$	Note 5
Optical output	Maximum power wavelength	+10dBm [typ]	Note 2
	1520 to 1570nm	$\geq +7\text{dBm}$	
	1500 to 1580nm	$\geq +5\text{dBm}$	
	1480 to 1580nm	$\geq +3\text{dBm}$	
Optical changeable attenuation function		$\geq 20\text{dB}$	Note 6
Optical output stability	For five minutes	$\leq \pm 0.01\text{dB}$	Note 2, Note 9
	For one hour	$\leq \pm 0.05\text{dB}$	Note 2, Note 7, Note 9
	For eight hours	$\leq \pm 0.3\text{dB}$	Note 2, Note 8, Note 9
Optical output accuracy		$\leq \pm 1\text{dB}$	Note 2, Note 3, Note 9
Optical output repeatability		$\pm 0.04\text{dB}$	Note 2, Note 3, Note 7, Note 9, Note 10
Optical output flatness		$\pm 0.1\text{dB}$	Note 2, Note 3, Note 9, Note 11
RIN		-145dB/Hz [typ]	
Internal modulation (CHOP)	Set frequency	0.2kHz to 300kHz	Note 12
	Set resolution	10Hz, 100Hz, 1kHz, 10kHz, 100kHz	
External modulation (CHOP)	Set frequency	0.2kHz to 300kHz	
	Set resolution	-	
Direct modulation	Modulation degree	Maximum $\leq 5\%$	Note 13
Wavelength sweep speed		100nm/sec (maximum)	
Applicable fiber		SMF (10/125 μm)	
Applicable optical connector		FC/PC, Amount of optical reflection attenuation $\leq 50\text{dBm}$	Note 14
Dimensions		Approx. 177(H) x 425(W) x 450(D) mm	
Weight		Approx. 20kg	
Range of operation temperature		+10 to +35°C	
Range of storage temperature		-10 to +50°C	
Humidity condition		$\leq 80\%$	Note 15
Power supply	Range of voltage	100 to 120VAC or 200 to 240VAC	
	Frequency	50/60Hz	
	Consumption electric power	Approx. 150VA	
Attached goods		Instruction manual : 1 Power cord : 1 Floppy disks : 2 AQ9441(FC)connector adapter : 1 50-ohm terminator : 1	

Note 1 : 23°C fixed temperature, 2 σ (Within one hour after wavelength calibration succeeds), Line width NARROW, SWEEP FINE, OPT ATT CONT.

Note 2 : CW light output, Measured at the output end of 2 m-long, When one hour or more has passed since power supply was turned on

Note 3 : Optical output $\leq +3\text{dBm}$

Note 4 : Immediately after wavelength calibration 1520nm, Line width NARROW, SWEEP FINE, OPT ATT CONT.

Note 5 : Optical output $\geq +7\text{dBm}$ (1550nm)

Note 6 : Step 0.1dB, Maximum power wavelength, OPT ATT CONT.

Note 7 : Within $\pm 1^\circ\text{C}$ of 10 to 35°C

Note 8 : 10 to 35°C

Note 9 : Line width WIDE

Note 10 : Optical output level fixation

Note 11 : Wavelength 1500 to 1580nm

Note 12 : Duty=50 \pm 5%

Note 13 : Modulation frequency=100kHz to 300MHz, Set input Modulation level $\leq 0\text{dBm}$.

Note 14 : Consult us for other connectors

Note 15 : No do de dewy

Ta=23°C, CW light output, Measured at the output end of 2 m-long, When one hour or more has passed since power supply was turned on

Table 1-1: AQ4321 specifications (2 of 4)

Model		AQ4321D	Note
Wavelength changeable width		1520 to 1620nm	
Wavelength resolution		0.001nm	
Absolute wavelength accuracy		$\leq \pm 0.015\text{nm} \pm 0.01\text{nm}[\text{typ}]$	Note 1, Note 2, Note 3
		$\leq \pm 0.01\text{nm}$	Note 2, Note 3, Note 4
Relative wavelength accuracy		$\leq \pm 0.01\text{nm}[\text{typ}]$	Note 1, Note 2, Note 3
Wavelength stability		$\pm 100\text{MHz/h} (\pm 0.8\text{pm/h})[\text{typ}]$	Note 3
Width of spectrum line	When NARROW is set	200MHz[typ]($\leq 1\text{MHz}$)	Note 2
	When WIDE is set	$\geq 100\text{MHz}, 200\text{MHz}[\text{typ}]$	
SMSR		$\geq 50\text{dB}$	Note 5
Optical output	Maximum power wavelength	+7dBm[typ]	Note 2
	1560 to 1600nm	$\geq +6\text{dBm}$	
	1540 to 1620nm	$\geq +5\text{dBm}$	
	1520 to 1620nm	$\geq +3\text{dBm}$	
Optical changeable attenuation function		$\geq 20\text{dB}$	Note 6
Optical output stability	For five minutes	$\leq \pm 0.01\text{dB}$	Note 2, Note 9
	For one hour	$\leq \pm 0.05\text{dB}$	Note 2, Note 7, Note 9
	For eight hours	$\leq \pm 0.3\text{dB}$	Note 2, Note 8, Note 9
Optical output accuracy		$\leq \pm 1\text{dB}$	Note 2, Note 3, Note 9
Optical output repeatability		$\pm 0.04\text{dB}$	Note 2, Note 3, Note 7, Note 9, Note 10
Optical output flatness		$\pm 0.1\text{dB}$	Note 2, Note 3, Note 9, Note 11
RIN		-145dB/Hz[typ]	
Internal modulation (CHOP)	Set frequency	0.2kHz to 300kHz	Note 12 : Duty=50±5%
	Set resolution	10Hz, 100Hz, 1kHz, 10kHz, 100kHz	
External modulation (CHOP)	Set frequency	0.2kHz to 300kHz	
	Set resolution	-	
Direct modulation	Modulation degree	Maximum $\leq 5\%$	Note 13
Wavelength sweep speed		100nm/sec (maximum)	
Applicable fiber		SMF (10/125 μm)	
Applicable optical connector		FC/PC, Amount of optical reflection attenuation $\leq 50\text{dBm}$	Note 14
Dimensions		Approx. 177(H) x 425(W) x 450(D) mm	
Weight		Approx. 20kg	
Range of operation temperature		+10 to +35°C	
Range of storage temperature		-10 to +50°C	
Humidity condition		$\leq 80\%$	Note 15
Power supply	Range of voltage	100 to 120VAC or 200 to 240VAC	
	Frequency	50/60Hz	
	Consumption electric power	Approx. 150VA	
Attached goods		Instruction manual : 1 Power cord : 1 Floppy disks : 2 AQ9441(FC)connector adapter : 1 50-ohm terminator : 1	

Note 1 : 23°C fixed temperature, 2 σ (Within one hour after wavelength calibration succeeds), Line width NARROW, SWEEP FINE, OPT ATT CONT1

Note 2 : CW light output, Measured at the output end of 2 m-long, When one hour or more has passed since power supply was turned on

Note 3 : Optical output $\leq +3\text{dBm}$

Note 4 : Immediately after wavelength calibration 1520nm, Line width NARROW, SWEEP FINE, OPT ATT CONT1

Note 5 : Optical output $\geq +6\text{dBm}$ (1590nm)

Note 6 : Step 0.1dB, Maximum power wavelength, OPT ATT CONT1

Note 7 : Within $\pm 1^\circ\text{C}$ of 10 to 35°C

Note 8 : 10 to 35°C

Note 9 : Line width WIDE

Note 10 : Optical output level fixation

Note 11 : Wavelength 1500 to 1580nm

Note 12 : Duty=50±5%

Note 13 : Modulation frequency=100kHz to 300MHz, Set input Modulation level $\leq 0\text{dBm}$

Note 14 : Consult us for other connectors

Note 15 : No do be dewy

Ta=23°C, CW light output, Measured at the output end of 2 m-long, When one hour or more has passed since power supply was turned on

Table 1-1 Specifications show the specifications of the unit.

Table 1-1 Specifications

Usable Fibers		Single mode fiber
Measuring wavelength range		1200 ~1700 nm (Vacuum wavelength)
Wavelength accuracy	(Note)	±0.02 nm (1520~1580nm) ±0.05 nm (1580~1620nm) ±0.3 nm (1200~1700nm)
Wavelength linearity	(Note)	±0.01 nm (1520~1580nm) ±0.02 nm (1580~1620nm)
Wavelength reproducibility	(Note)	±0.005 nm (1 min.)
Wavelength resolution	(Note)	Max. resolution: 0.05 nm (1520~1620nm) Resolution settings: 0.05,0.1, 0.2, 0.5, 1.0 nm Resolution accuracy: ±5% (Resolution above 0.2 nm)
Measuring level range	(Note)	-90~+20dBm (1200~1600nm, measuring sensitivity HIGH 3) -80~+20dBm (1600~1700nm, measuring sensitivity HIGH 3)
Level accuracy	(Note)	±0.3 dB typ.(1550/1600 nm, measuring sensitivity, HIGH1~3, Resolution above 0.1nm, input -30 dBm)
Polarization dependency	(Note)	±0.05 dB (1550/1600nm, Resolution above 0.1nm)
Level linearity	(Note)	±0.05 dB (Input 0 to -50 dB, measuring sensitivity HIGH 1~3 Resolution above 0.1nm)
Level flatness	(Note)	±0.1 dB (1520~1580nm, Resolution above 0.1nm) ±0.1 dB (1580~1620nm, Resolution above 0.1nm)
Level reproducibility	(Note)	±0.02 dB (1550/1600nm,Input -23dBm, for 1 minute Resolution above 0.1nm)
Dynamic range	(Note)	40 dB (1523 nm, peak ±0.2 nm, resolution 0.05nm, measuring sensitivity HIGH1~3) 55 dB (1523 nm, peak ±0.4 nm, resolution 0.05nm measuring sensitivity HIGH1~3)
Light input connector return loss		30 dB typ. (1550/1600nm)
Sweep time		Within 500 ms (Span 50 nm less than, measuring sensitivity NORMAL HOLD, average number of times 1 sample AUTO)
Function	Automatic measurement	Program function (5 programs, 200 steps) Long term function
	Setting of measuring conditions	Span setting: 0 to 500 nm Measuring sensitivity settings: NORMAL HOLD/AUTO, HIGH 1/2/3 No. of averagings setting: 1~1000 Sample number setting: 11~20001, AUTO Automatic setting function of measuring conditions by automatic sweep Sweep-between-marker function 0 nm sweep function Pulse light averaging measurement function