

γ irradiation induced effects on bismuth active centres and related photoluminescence properties of Bi/Er co-doped optical fibers

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Supplementary materials

Sample	SA1	SA2	SA3	SA4	SA5		
Length of the BEDF (cm)	30.5	31.6	30.5	31.0	31.0		
Dose (kGy)	1	5	15	30	50		
	Measured parameter	Measuring conditions					
Small signal absorption	$\alpha@1300$ nm (dB)	Before irradiation	17.8	10.9	10.8	10.6	11.4
	$\alpha@1300$ nm (dB)	After irradiation	16.5	9.1	10.4	9.8	10.3
Pump absorption	$\alpha_{max}@830$ nm (dB/m)	Before irradiation	58.4	55.0	56.4	53.1	52.2
	$\alpha_s@830$ nm (dB/m)		45.3	41.2	40.0	36.1	32.8
	$\alpha_{us}@830$ nm (dB/m)		13.2	13.8	16.4	17.0	19.4

	α_{\max} @830 nm (dB/m)	After irradiation	72.5	71.3	77.2	86.9	91.0
	α_s @830 nm (dB/m)		51.0	41.2	40.4	44.5	46.1
	α_{us} @830 nm (dB/m)		21.5	30.1	36.7	42.3	44.9

Supplementary Table S1. The values of the attenuation related parameters measured before and after gamma irradiation.

Sample		SA1	SA2	SA3	SA4	SA5	
Forward emission	$e_2(\lambda)$ at maximum pumping	Before irradiation	√	√	√	√	√
		After irradiation	√	√	√	√	√
	$e_2(1410)/e_2(1540)$	Before irradiation	√	√	√	√	√
		After irradiation	√	√	√	√	√
		Variation	√	√	√	√	√
	$e_2(1100)/e_2(1540)$	Before irradiation	√	√	√	√	√
		After irradiation	√	√	√	√	√
		Variation	√	√	√	√	√
	$e_2(1100)/e_2(1410)$	Before irradiation	√	√	√	√	√

		After irradiation	√	√	√	√	√
		Variation	√	√	√	√	√
	$e_2(\lambda)$ at different pump power	Before irradiation	√	√	√	√	√
		After irradiation	√	√	√	√	√
Emission under different pumping conditions	$e_2(1410)$ vs pump power	Before irradiation	√	√	√	√	√
		After irradiation	√	√	√	√	√
	P_{sat}	Before irradiation	√	√	√	√	√
		After irradiation	√	√	√	√	√
	$P_{\text{sat}}(\text{after})/ P_{\text{sat}}(\text{before})$	Variation	√	√	√	√	√

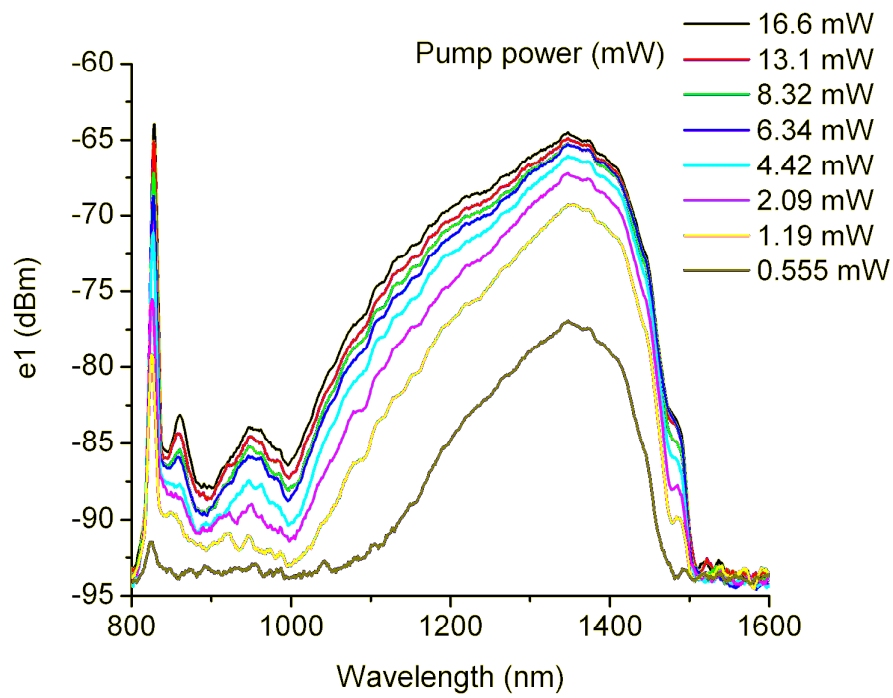
Supplementary Table S2. Emission related tests performed pre and post gamma irradiation.

Measurement conditions	Sample	Sample	Sample
	Dose (kGy)	Dose (kGy)	Dose (kGy)
	SA2	SA3	SA5
	5 kGy	15 kGy	50 kGy
Pump power before irradiation (mW)	27.3	30.7	44.1
Pump power after irradiation (mW)	29.1	35.7	44.1

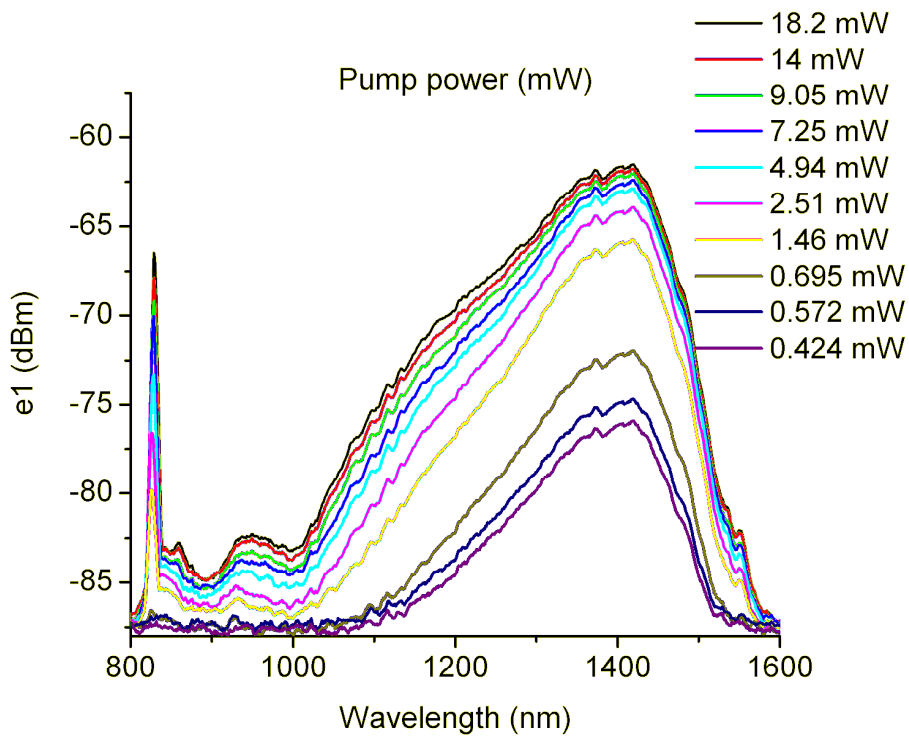
Supplementary Table S3. The pump power for emission tests - before and after the 5 kGy, 15 kGy, 50 kGy dose irradiations.

Sample name	Sample constituents	Total irradiation dose (kGy)
SA-1	SMF@1300 (1.2 m) + BEDF (30.5 cm) + SMF@1550 (2 m)	1
SA-2	SMF@1300 (1.2 m) + BEDF (30 cm) + SMF@1550 (2 m)	5
SA-3	SMF@1300 (1.2 m) + BEDF (31.6 cm) + SMF@1550 (2 m)	15
SA-4	SMF@1300 (1.2 m) + BEDF (30 cm) + SMF@1550 (2 m)	30
SA-5	SMF@1300 (1.2 m) + BEDF (30.5 cm) + SMF@1550 (2 m)	50

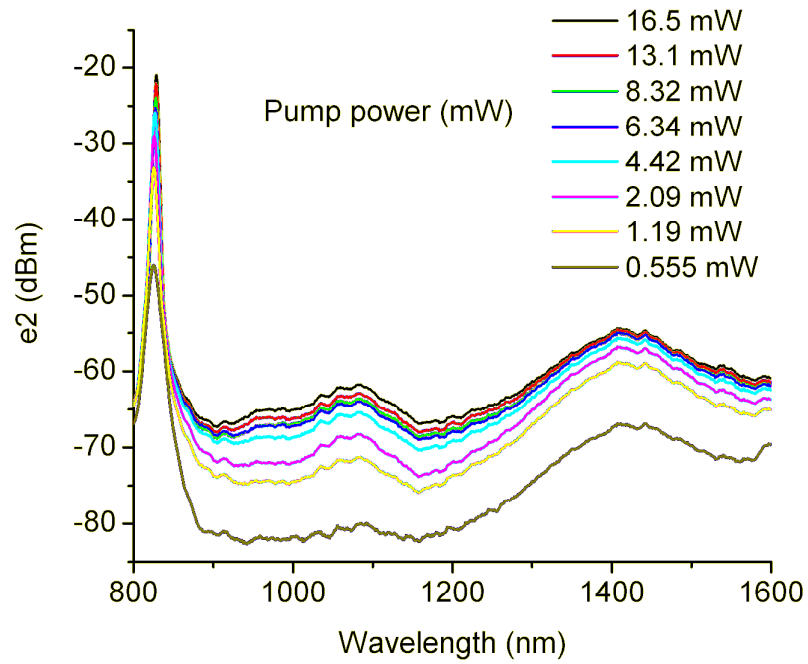
Supplementary Table S4. The investigated samples and the irradiation conditions.



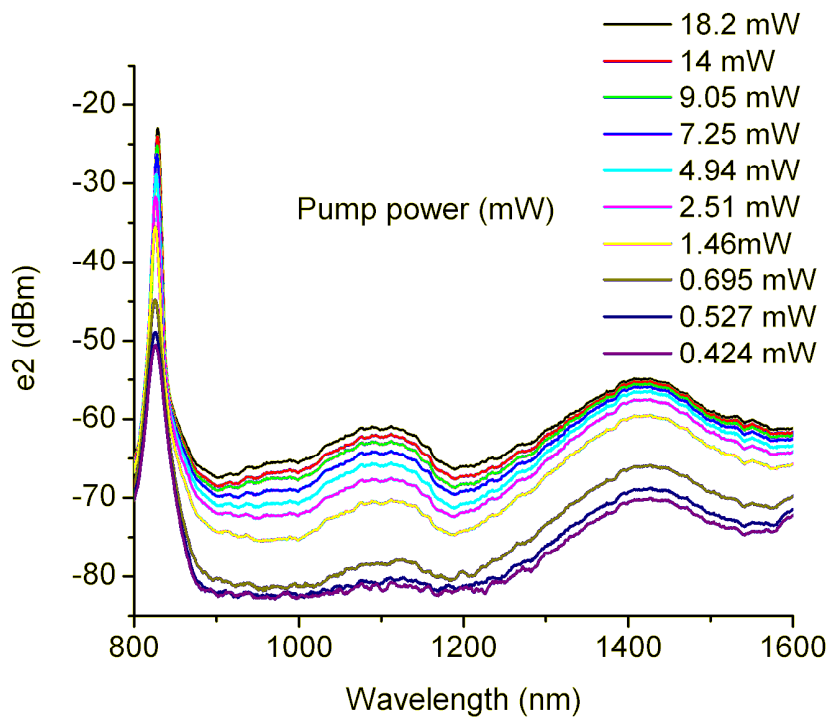
a



b

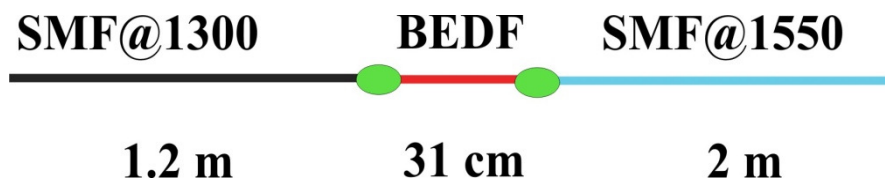


c

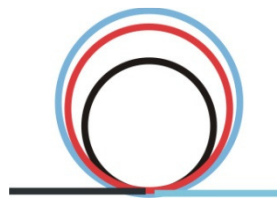


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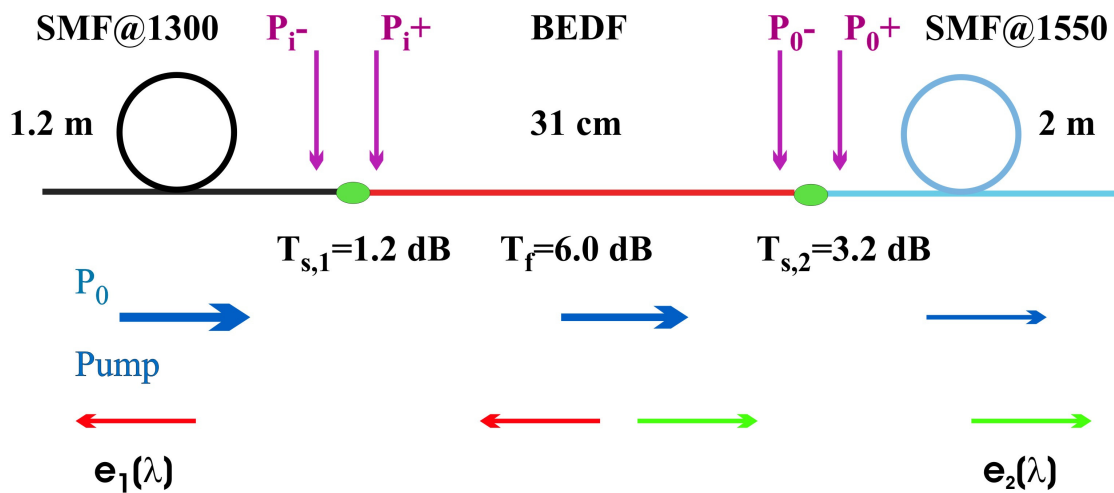
Supplementary Figure S1. The dependence on the pump power of: the backward $e_1(\lambda)$ propagated spectral emission for sample SA1 before (a) and after (b) 1 kGy gamma irradiation; the forward $e_2(\lambda)$ propagated spectral emission for sample SA1 before (c) and after (d) 1 kGy gamma irradiation, pump power at 830 nm.



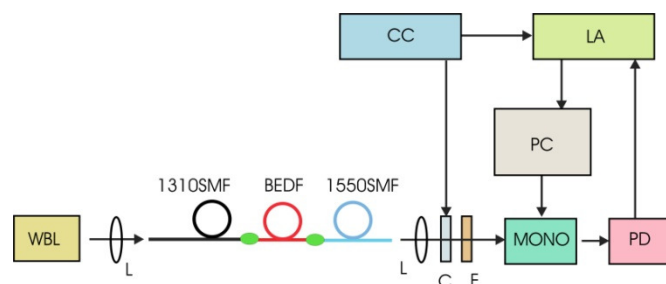
Supplementary Figure S2. The sketch of the SA optical fiber sample.



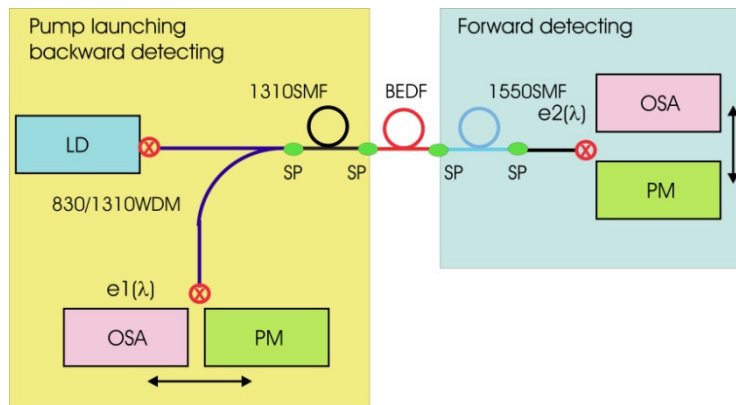
Supplementary Figure S3. The sample geometry during the irradiation



Supplementary Figure S4. The optical power measuring points for the spectral emission of the tested sample SA5 (50 kGy), used for investigations done before and after the irradiation: P_0 – the pump power; P_{i-} – the optical power at the input of the splicer coupling the SMF@1300 to BEDF; P_{i+} – the optical power at the output of the splicer coupling the SMF@1300 to BEDF; P_{0-} – the optical power at the input of the splicer coupling the BEDF to the SMF@1550; P_{0+} – the optical power at the output of the splicer coupling the BEDF to the SMF@1550; $T_{s,1}$ – transmission losses in the splicer coupling the SMF@1300 to the BEDF; $T_{s,2}$ – transmission losses in the splicer coupling the BEDF to the SMF@1550; T_f – transmission losses in the BEDF.



Supplementary Figure S5. The setup for spectral attenuation evaluation: WBL – wide band lamp; L – lens; F – filter; C – copper; CC – chopper controller; LA – lock-in amplifier; MONO – monochromator; PD – photodiode; PC – desk top computer.



Supplementary Figure S6. The setup for spectral emission measurements: LD – laser diode; OSA – optical spectrum analyser; PM – power meter; SP – splice.