Role of the FBG's bandwidth in long distance point sensing system based on random fiber laser (P3.2)

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Abstract

◆ We study the influence of the fiber Bragg grating (FBG)'s bandwidth on the performance of the long distance point sensing system based on random fiber laser. The results show that the optical signal-to-noise ratio (OSNR) decreases gradually when the bandwidth of the FBG increases by simulation, under the same pump power, which is demonstrated by the experiment.

◆ This work could provide a reference for designing a long-distance optical fiber sensing system.

Operation Principles

◆ The schematic setup of the RFL system utilizing the second-order random laser is depicted in Fig.1. Keep the pump power constant, and record the optical signal-to-noise ratio(OSNR) by changing the bandwidth of the tail-end sensing FBG with 1560nm center wavelength in sensing system.

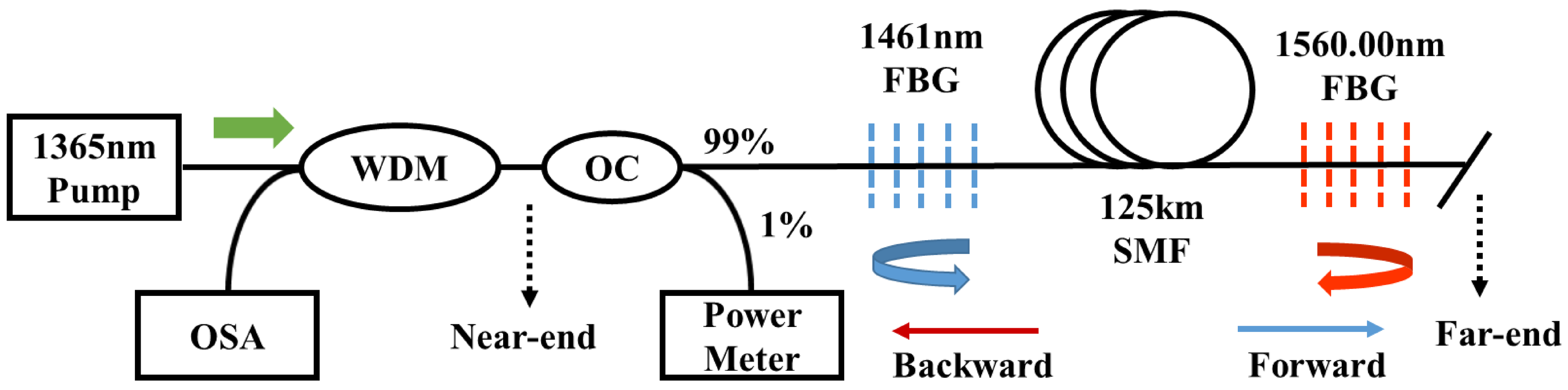

Fig. 1. *The Schematic setup.*

◆ For theoretically analyzing the OSNR of the RFL, extend the modified power balance model [1] to second-order random laser to describe spectrum.

The set of equations :

$$\frac{dP_0^{\pm}}{dz} = \mp\alpha_0 P_0^{\pm} \mp g_1 \frac{f_0}{f_1} P_0^{\pm}(P_1^{+} + P_1^{-} + \Gamma_1) \pm \varepsilon_0 P_0^{\mp}$$

$$\frac{dP_1^{\pm}}{dz} = \mp\alpha_1 P_1^{\pm} \pm g_1 (P_1^{\pm} + 0.5\Gamma_1)(P_0^{+} + P_0^{-}) \mp \sum_{i=1}^{n} \frac{f_1}{f_{2\lambda_i}} P_1^{\pm}\left(g_{2\lambda_i}(P_{2\lambda_i}^{+} + P_{2\lambda_i}^{-})d\lambda_i + \Gamma_{2\lambda_i}\right) \pm \varepsilon_1 P_1^{\mp}, \quad i = 1,\ldots,n$$

$$\frac{dP_{2\lambda_i}^{\pm}}{dz} = \mp\alpha_{2\lambda_i} P_{2\lambda_i}^{\pm} \pm g_{2\lambda_i}(P_{2\lambda_i}^{\pm} + 0.5\Gamma_{2\lambda_i})(P_1^{+} + P_1^{-}) \pm \varepsilon_{2\lambda_i} P_{2\lambda_i}^{\mp}, \quad i = 1,\ldots,n$$

$$\Gamma_1 = 4hf_1\Delta f_1 \left\{1 + \frac{1}{\exp[h(f_0 - f_1)/K_B T] - 1}\right\}$$

$$\Gamma_{2\lambda_i} = 4hf_{2\lambda_i}\Delta f_{2\lambda_i} \left\{1 + \frac{1}{\exp[h(f_1 - f_{2\lambda_i})/K_B T] - 1}\right\}, \quad i = 1,\ldots,n$$

Results and Analysis

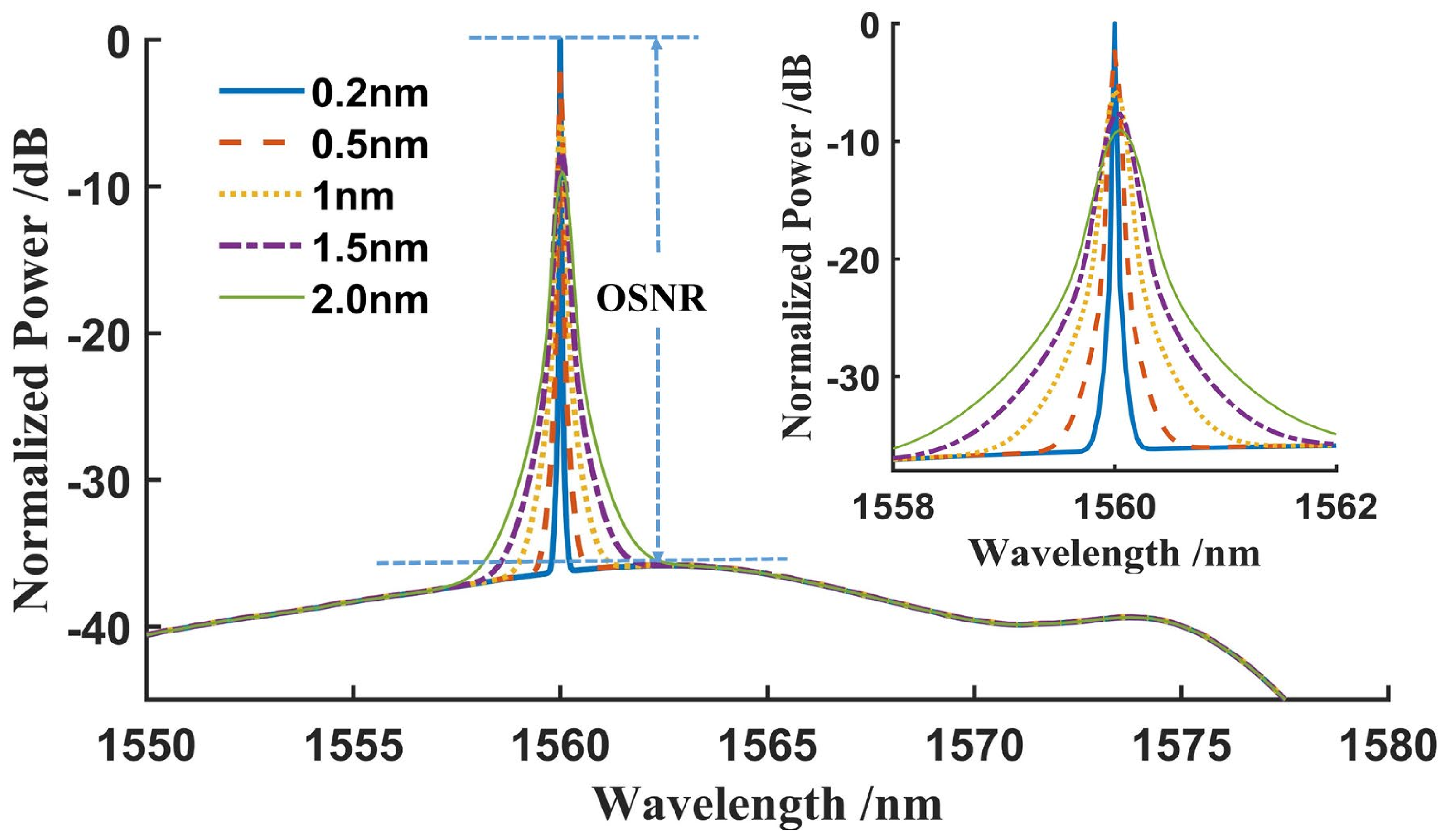

Fig. 2. *The simulation spectrum with different 3 dB bandwidth*

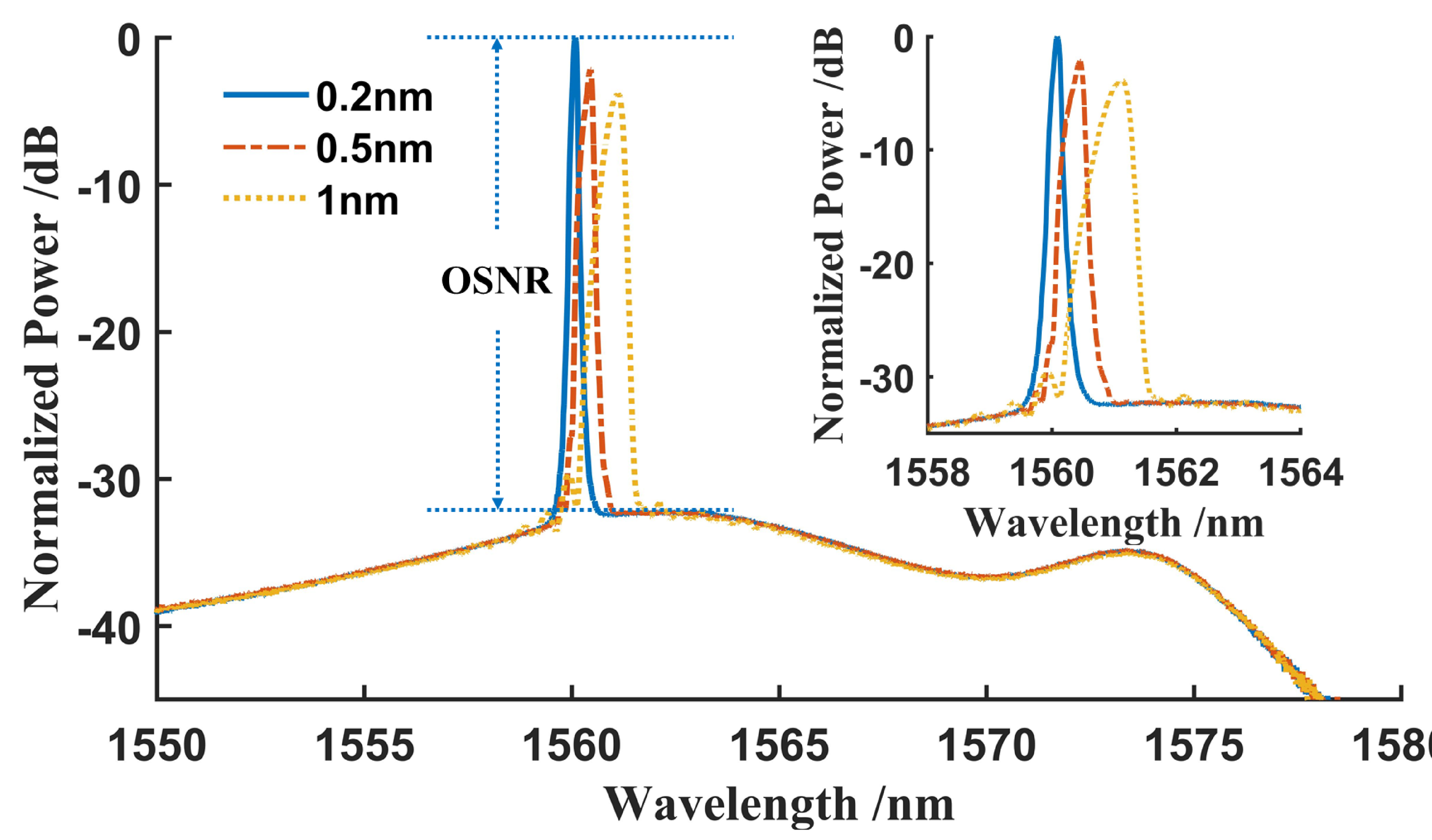

Fig. 3. *The measured spectrum with different 3 dB bandwidth.*

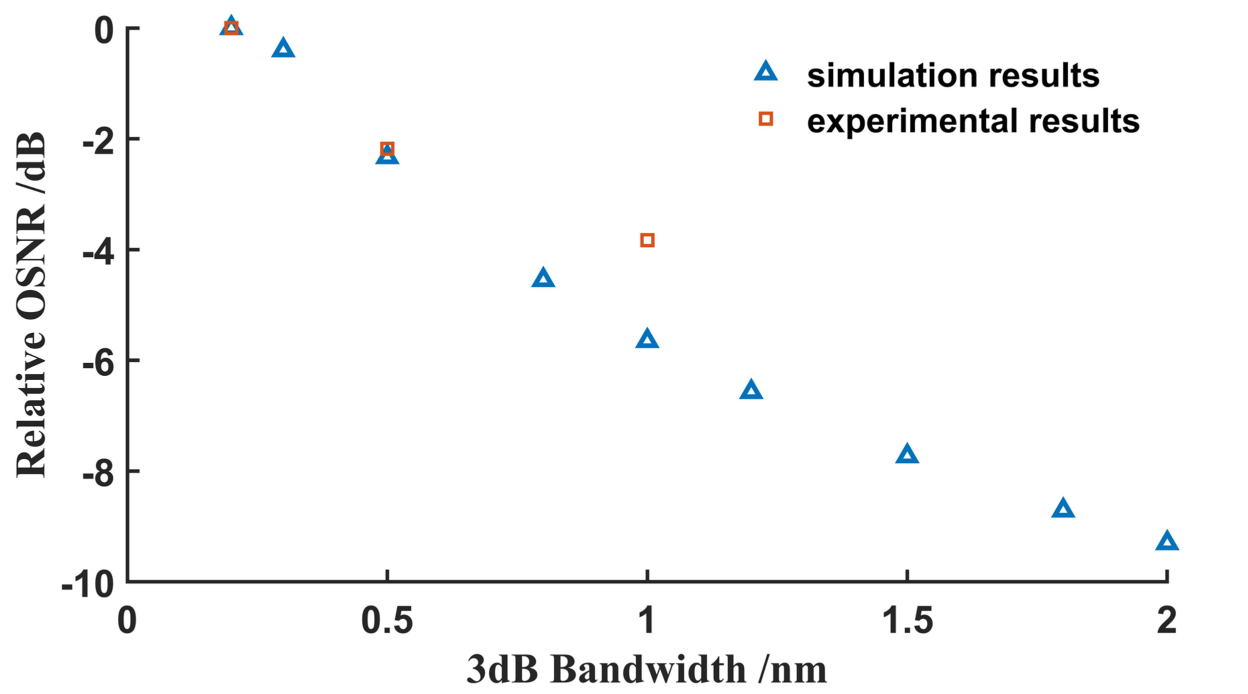

Fig. 4. *Comparison of simulation and experimental results.*

◆ From these results, we can found that as the FBG bandwidth increases, the OSNR of the sensor signals gradually decreases, at the same time, the trend between the simulation curve and the experimental curve match well.

Conclusions

◆ In this work, we extend the spectrum simulation model of the random fiber laser, then specifically analyze the influence of the FBG bandwidth on the OSNR of the sensing signal, which will decrease with the FBG bandwidth increasing.

◆ These results are useful for signal optimization of long-distance point sensing system based on random fiber laser.

References

1. Vatnik I D, Churkin D V, Modeling of the spectrum in a random distributed feedback fiber laser within the power balance modes, Proceedings of SPIE, May.2014, vol.9135, pp.91351Z, doi:10.1117/ 12.2052328.