The tangent function Q_1 of the phase angle of the first non-zero FFT term is a single-valued function of fluorescence lifespan. It is independent of the start light and background noise. We can calculate the fluorescence lifespan from E.g. (7)

$$\tau = \Delta t \ln\{[Q_1 \cos(2\pi / N) - \sin(2\pi / N)] / Q_1\}. \tag{8}$$

4. Experimental results and analyses

To compare with the several fitting methods, we adopt computer simulation and the model is as follows

$$f_k = \exp(-k \cdot \Delta t / \tau) + C_{rn} + B\,,\ \ k=0,1,\cdots,N-1. \tag{9}$$

Where Crn is the random noise. First, we compare the deviations by using the three different methods: log-fit method, FFT method, and Marquardt method under the random noise. The experimental result is show in Figure 3

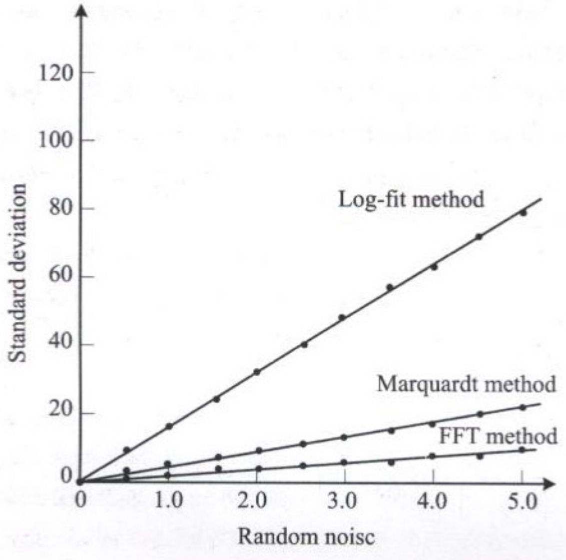

Fig. 3. The deviations by using different methods under the random noise.

It can be seen from Figure 3 that, of the three deviations, the deviation of FFT method is the smallest, which is close to the result of the Marquardt method, and the deviation of log-fit method is the largest.

Second, in a real system, the fluorescence signals are always intermixed together with the background noise. The influence of the background noise in different methods is indicated in Figure 4.

We can see from Figure 4 that the Marquardt method and the FFT method are immune from the background noise of the signal. The log-fit method is obviously influenced by the noise. Because the Marquardt method needs a recursive program that costs a lot of time, it cannot be adopted in systems in spite of its high accuracy.

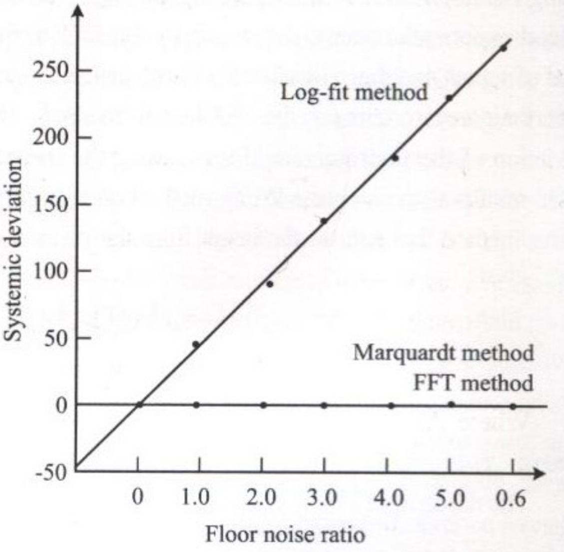

Fig. 4. The influence of the background noise under different methods.

5. Conclusions

A sapphire optic-fiber thermal probe with Cr^{3+} ion-doped end is developed by using the laser heated pedestal growth method. The fluorescence thermal probe offers advantages of compact structure, high performance and ability to withstand high temperature. In a detection rang from room temperature to 450℃, using the Fast Fourier Transform, the fluorescence lifetime is obtained as a tangent function of the phase angle of the non-zero terms in the FFT result. This method has advantages such as quick calculation, high accuracy and immunity to the background noise. This FFT method is compared with other traditional fitting methods, indicating that the standard deviation of the FFT method is about half of that of the Prony method and about 1/6 of that of the log-fit method. In addition, the FFT method is immune from the