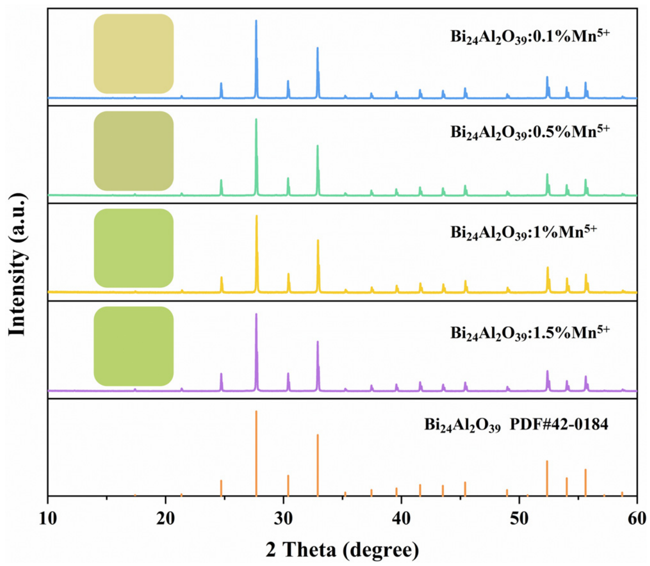

FIG. 1. XRD patterns of $Bi_{24}Al_2O_{39}$:x%Mn^{5+} phosphors and of the standard material (JCPDS No. 42-0184). Insets show the color of each phosphor sample.

diffraction peaks are consistent with the $Bi_{24}Al_2O_{39}$ phase. Moreover, doping with Mn^{5+} ions, which replace Al^{3+} ions, does not form the secondary phase or impurities. Figure S1 of the supplementary material shows XRD patterns from $Bi_{24}Al_2O_{39}$:0.5%Mn^{5+} phosphors sintered at different temperatures. In addition, the phosphor color changes from yellow to green upon increasing the Mn^{5+} doping concentration (see insets of Fig. 1) because the optical absorbance increases at 440 and 700 nm.[13] Figure S2 shows photographs of these samples.

Figures 2(a) and 2(b) present the photoluminescence (PL) spectra of $Bi_{24}Al_2O_{39}$:x%Mn^{5+}. Under 806 or 970 nm excitation, all PL spectra have sharp emission peaks corresponding to the $^1E \rightarrow {}^3A_2$ transition of Mn^{5+} ions. The $Bi_{24}Al_2O_{39}$:0.5%Mn^{5+} phosphor exhibits the highest luminescent intensity of all samples tested; its sharp emission peak (full width at half maximum = 20 nm) appears at 1253 nm. Given the signal-to-noise ratio, the $Bi_{24}Al_2O_{39}$:0.5%Mn^{5+} phosphor was further investigated for use as a luminescent thermometer.

Figures 2(c)–2(f) show temperature-dependent PL spectra produced by 806 or 970 nm excitation. The optical excitation was monitored to compensate for any fluctuations during data acquisition. Note that the 1612 nm peak is actually the second-order diffraction of the luminesce at 806 nm. Both 1612 and 970 nm peaks remain constant over the entire temperature range, whereas the 1253 nm peak of Mn^{5+} ions decreases significantly with increasing temperature.

When the excitation intensity is invariant, the single-emission LIR as a function of temperature may be expressed as[23,24]

$$LIR = \frac{I_T}{I_{300}} = C + B_1 T + B_2 T^2 + B_3 T^3, \quad (1)$$

where C, B_1, B_2, and B_3 are constants and T is the absolute temperature. I_T and I_{300} are the luminescence intensity at 1253 nm at temperature T and at 300 K, respectively. The single-emission LIR technique is insensitive to fluctuations in the excitation radiation and is also unaffected by optical dispersion, making it a highly reliable measurement technique.

Relative sensitivity Sr is an essential metric for evaluating thermometry methods. It is expressed as[25,26]

$$S_r = \frac{1}{LIR}\left|\frac{dLIR}{dT}\right|. \quad (2)$$

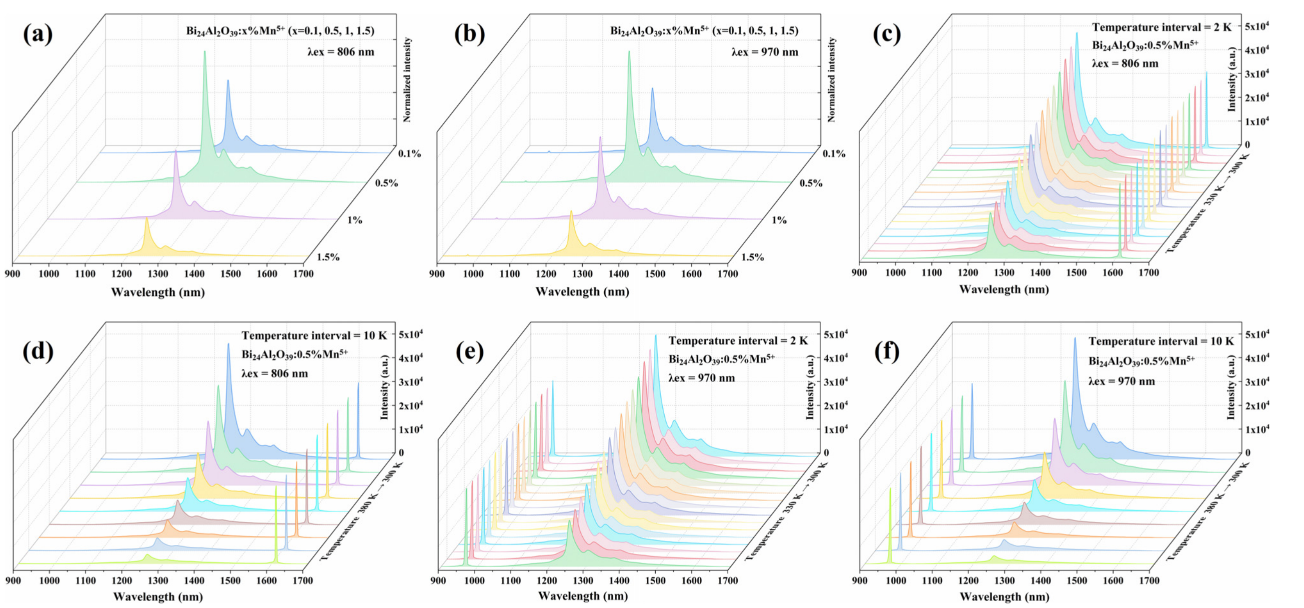

FIG. 2. PL spectra of $Bi_{24}Al_2O_{39}$:x%Mn^{5+} phosphors excited at (a) 806 nm and (b) 970 nm. Temperature-dependent PL at (c) and (e) 2 °C and (d) and (f) 10 °C intervals for $Bi_{24}Al_2O_{39}$:0.5%Mn^{5+} phosphor. The excitation wavelengths are given on the plots.