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Supplementary information

New Thorium-Bismuth Oxide Solid solutions with Oxygen Vacancy induced tunable ferromagnetism

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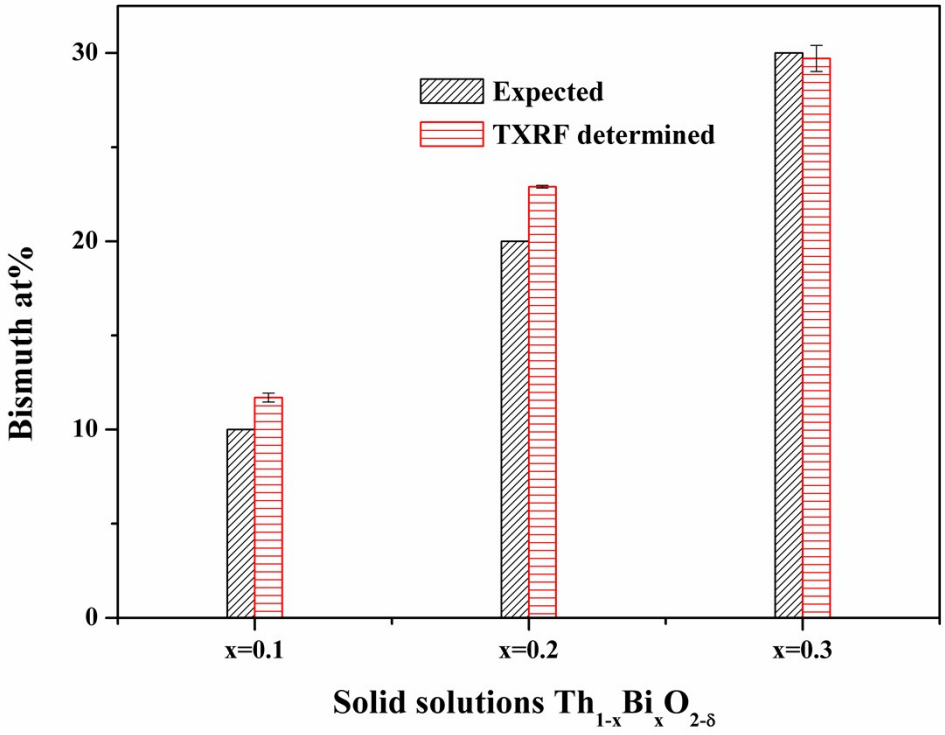

Figure S1: Comparison of TXRF determined Bi at% and expected (on the basis of preparation) Bi at% in $Th_{1-x}Bi_xO_{2-\delta}$ solid solutions

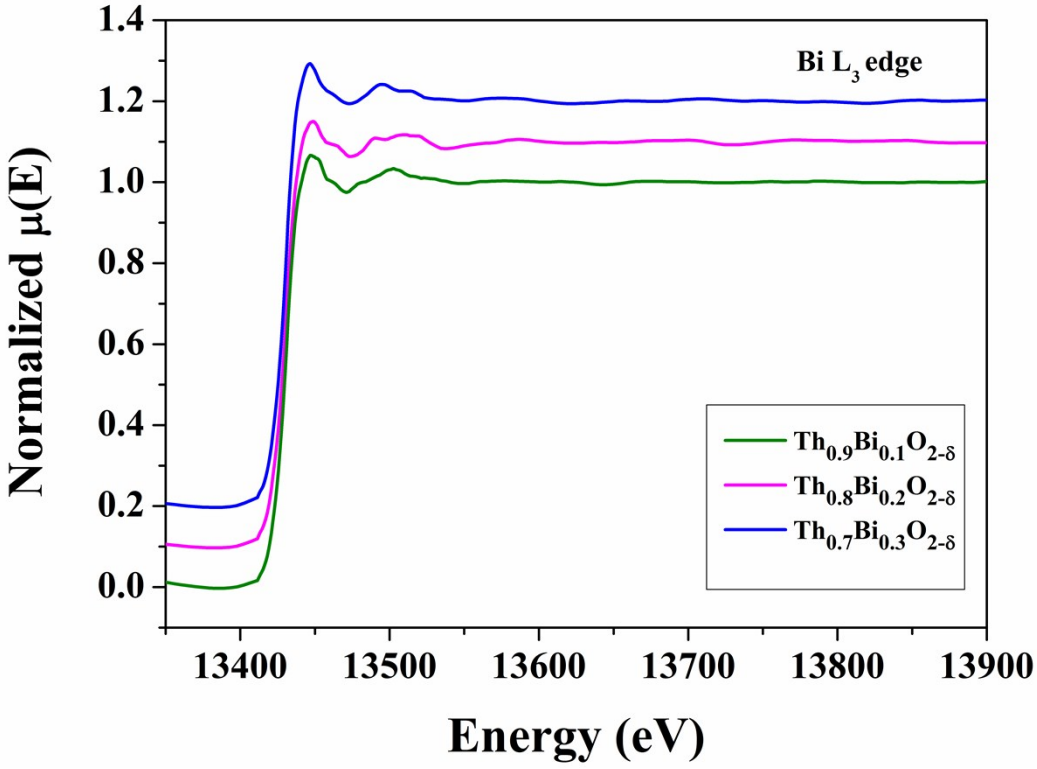

Figure S2: EXAFS spectra of the $Th_{1-x}Bi_xO_{2-\delta}$ solid solutions for x= 0.1, 0.2, and 0.3 measured at Bi L_3 edge

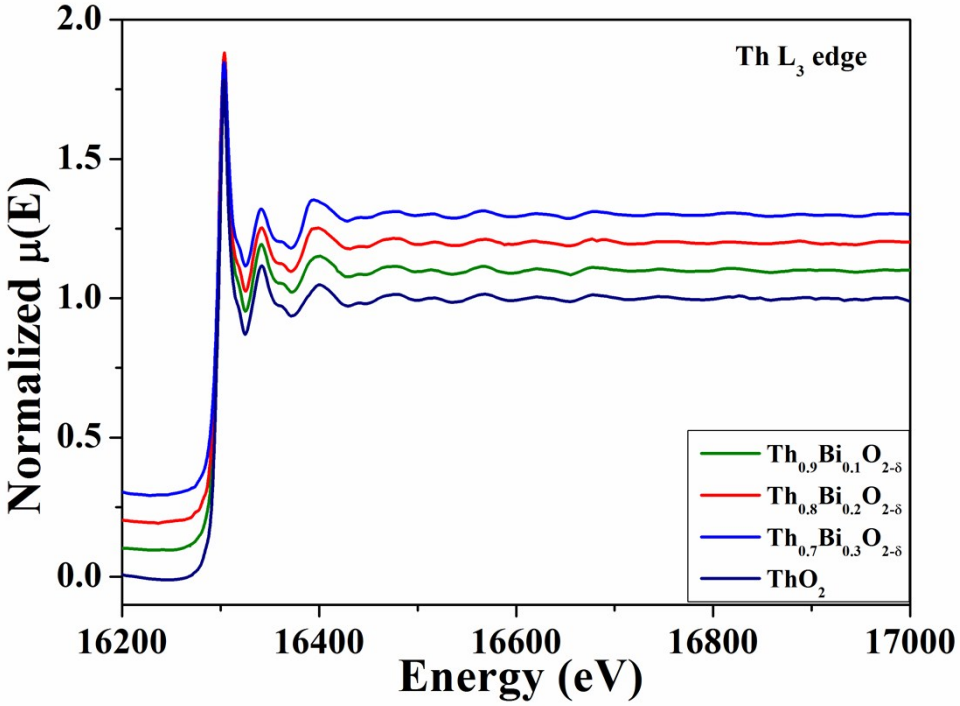

Figure S3: Experimental EXAFS ($\mu(E)$ versus E spectra of the $Th_{1-x}Bi_xO_{2-\delta}$ solid solutions for x= 0, 0.1, 0.2, 0.3 measured at Th L_3 edge

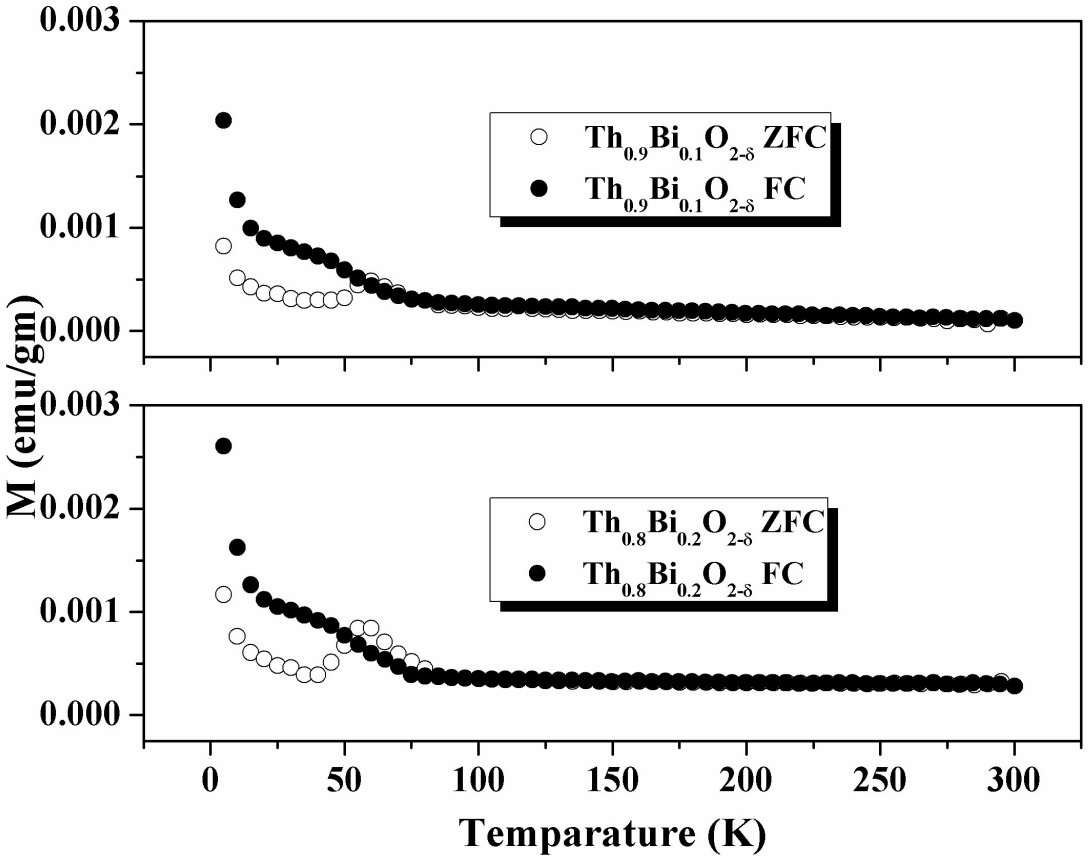

Figure S4: Magnetization (M) vs. Temperature (T) curve under FC and ZFC measurement for $Th_{1-x}Bi_xO_{2-\delta}$ for x=0.1and 0.2

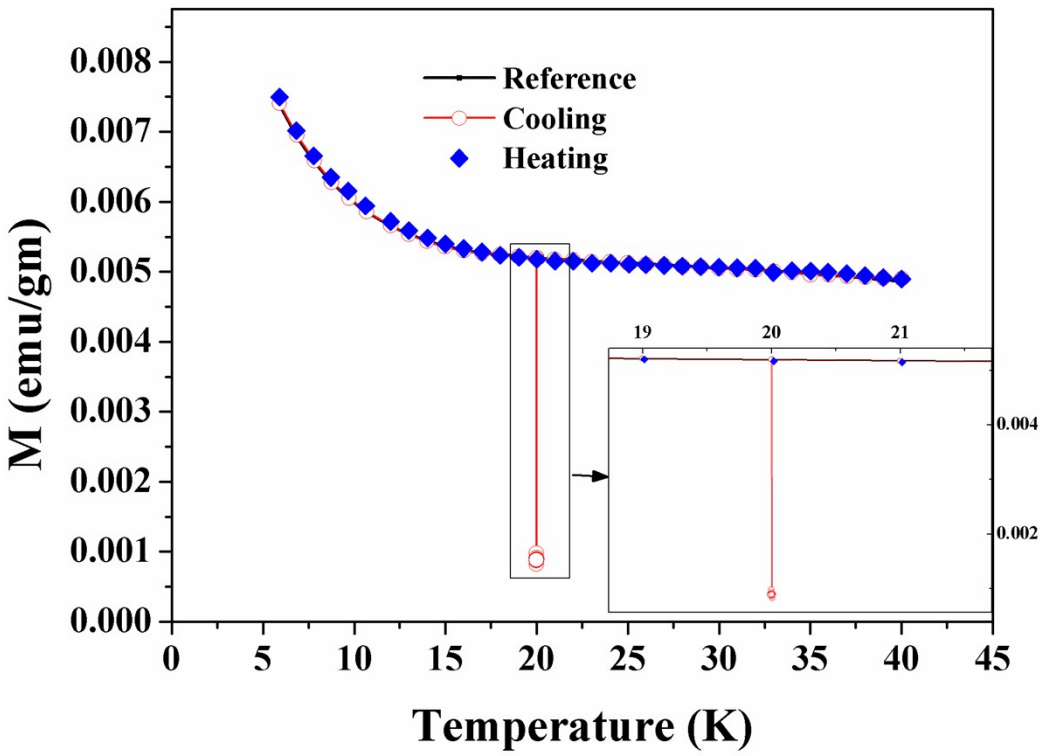

Figure S5: M(T) plot for memory effect study in dc magnetization measurement on $Th_{0.7}Bi_{0.3}O_{2-\delta}$. Solid line is measured data during heating (reference) at a constant heating rate of 2 K/min after FC in presence of 1000 oe field. Open circles are measured data during cooling at same cooling rate but with cooling stop at 20 K for 2 hours. Solid squares are measured data during heating. Inset figure is the enlarged view of the data near relaxation measurement

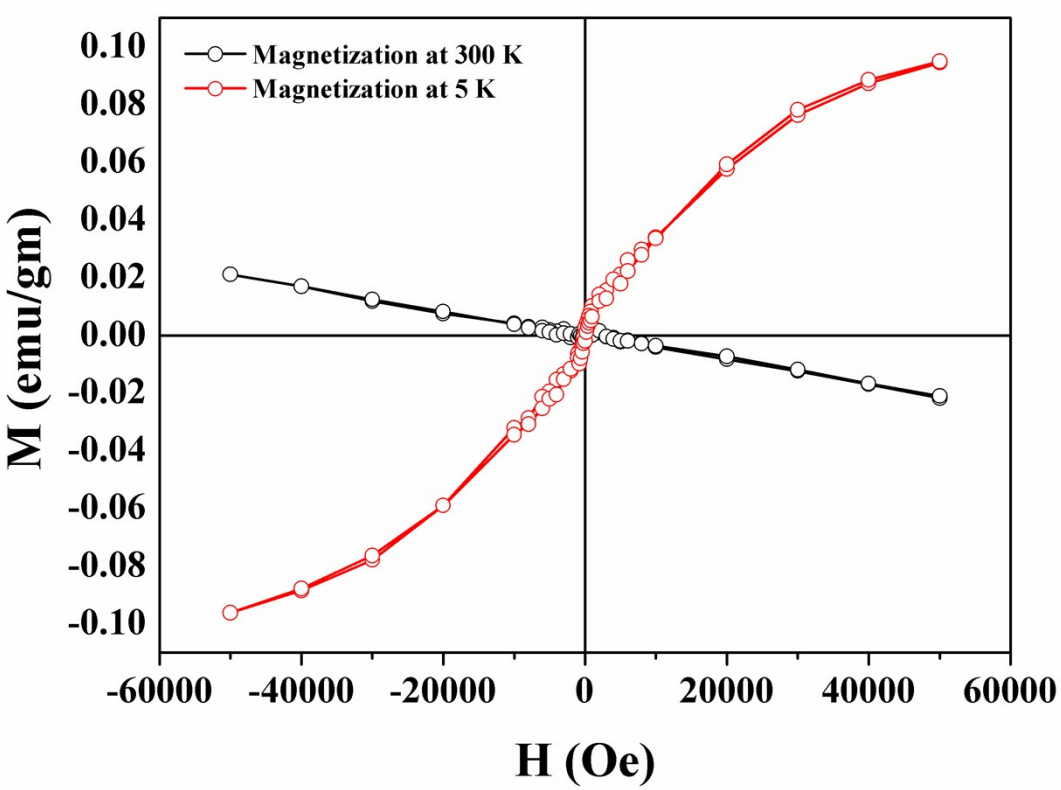

Figure S6: A field dependent dc magnetization measurement at 5K and 300K for $Th_{0.7}Bi_{0.3}O_{2-\delta}$

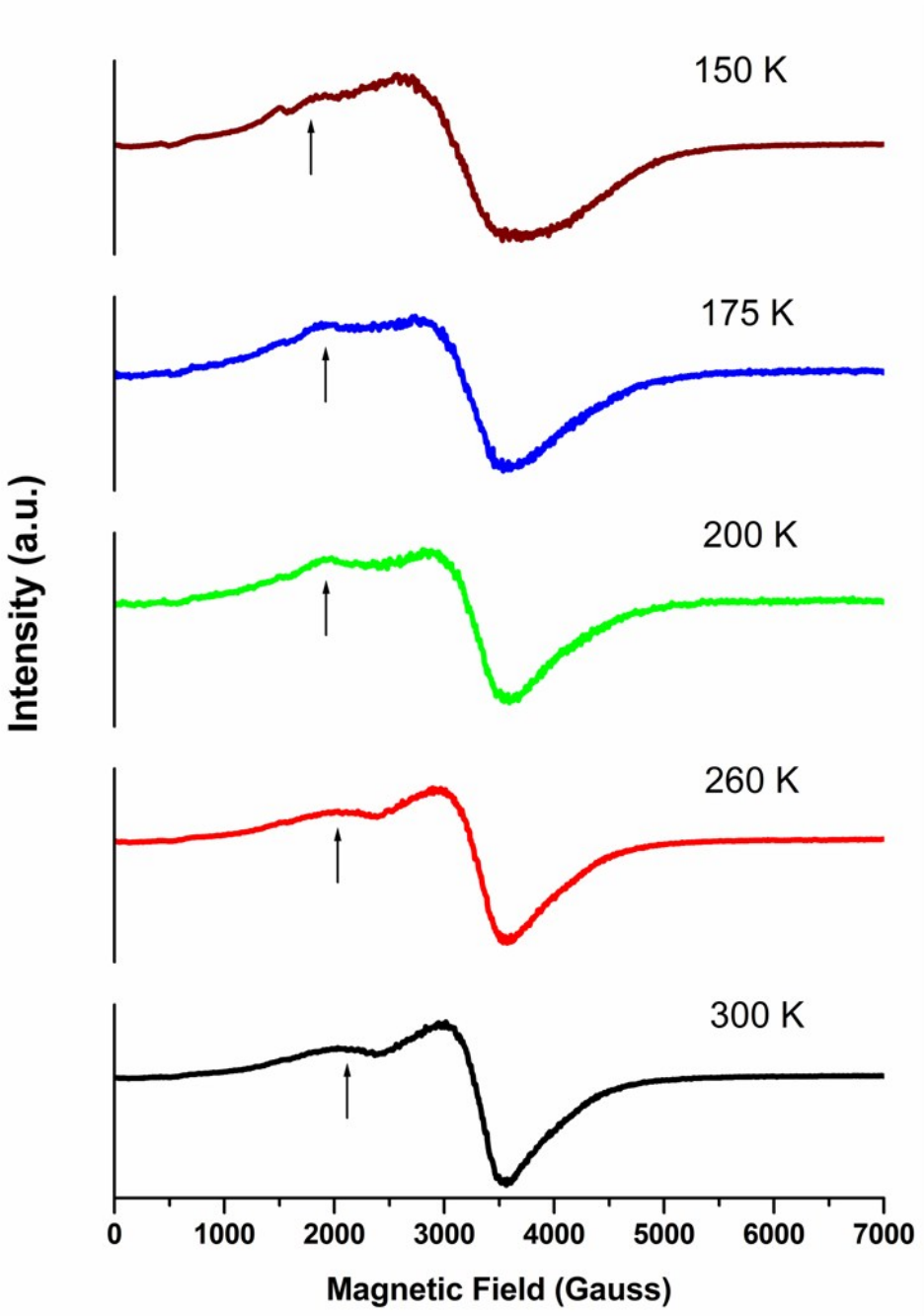

Figure S7: Temperature dependent EPR spectra of $Th_{0.9}Bi_{0.1}O_{2-\delta}$ *solid solutions (arrow indicate the FMR signal appearing as we are going to lower temperature)*

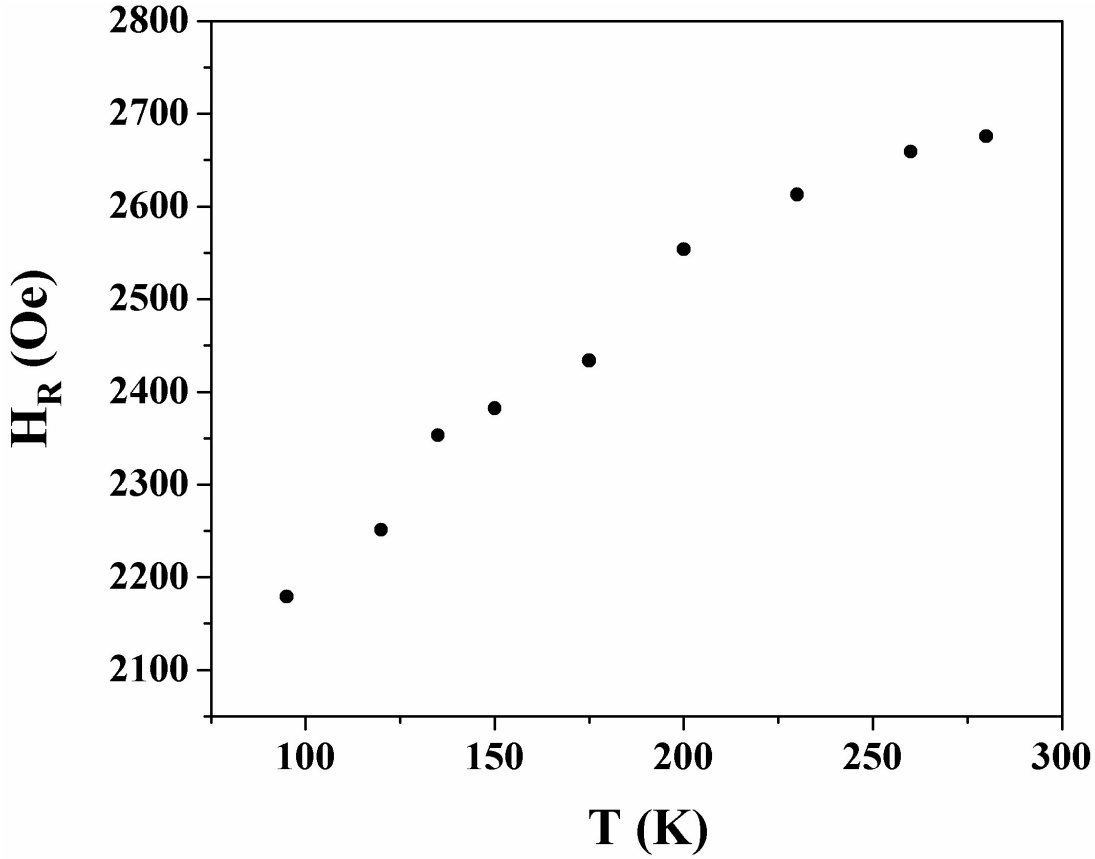

Figure S8: Temperature dependencies of resonance field, H_R of the FMR signal *$Th_{0.7}Bi_{0.3}O_{2-\delta}$ solid solutions*.

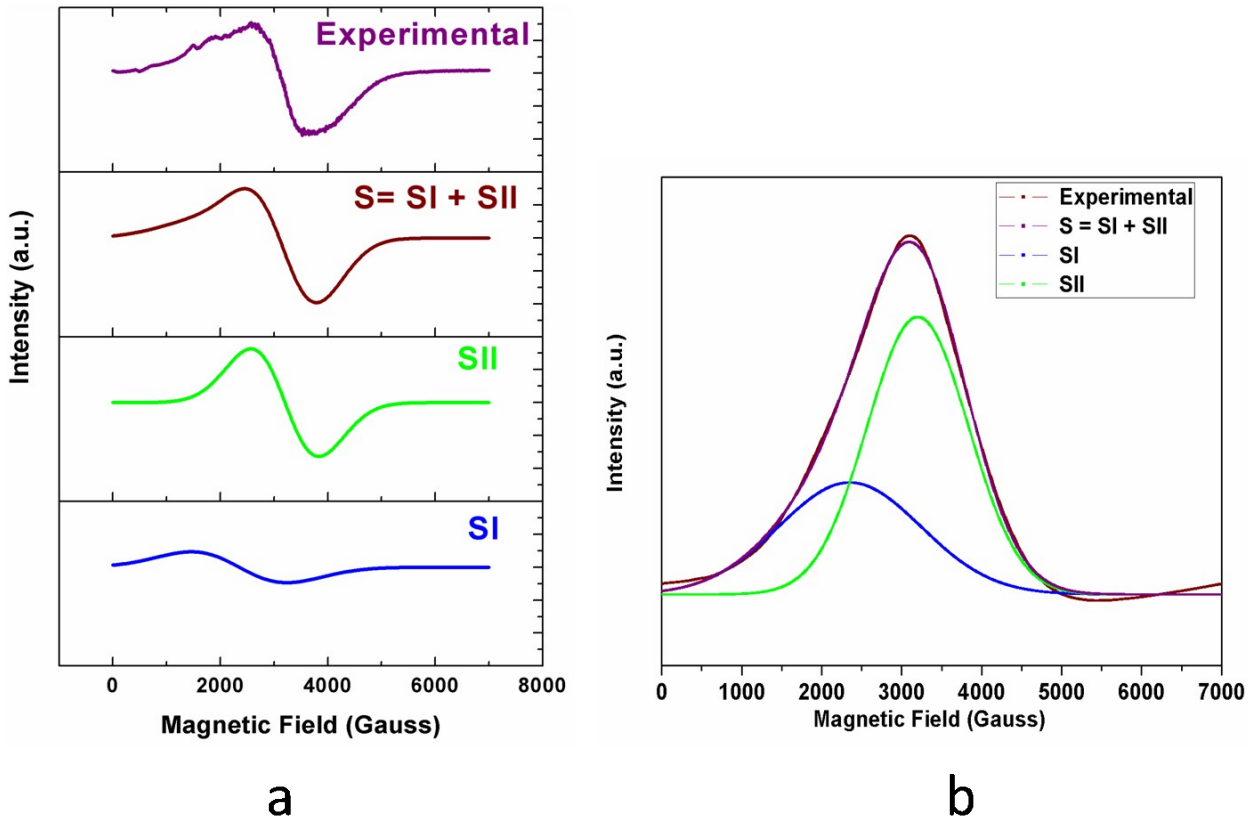

Figure S9: Gaussian fitted EPR spectrum of $Th_{0.9}Bi_{0.1}O_{2-\delta}$ *solid solutions at 150 K ; (a) Derivative spectra (b) Integrated spectra*

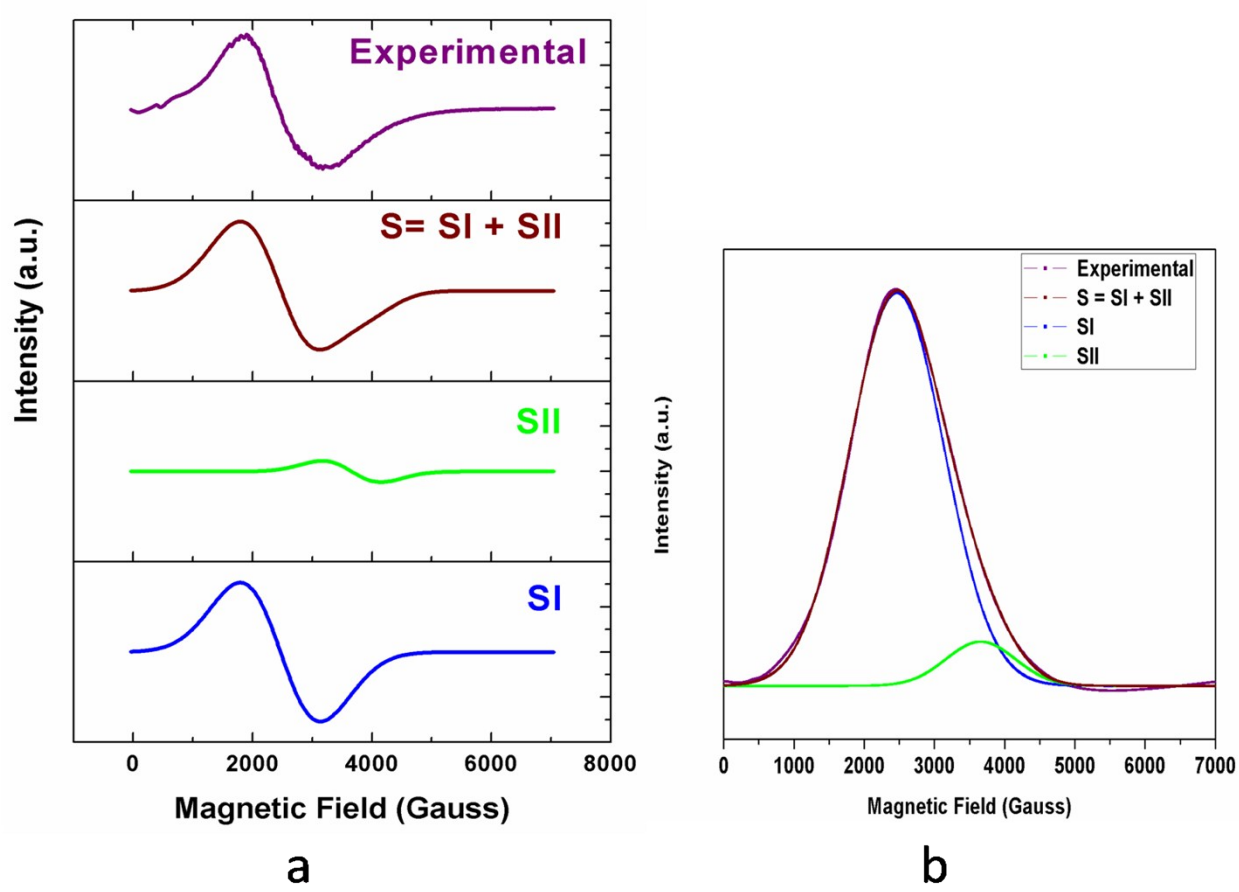

Figure S10: Gaussian fitted EPR spectrum of $Th_{0.7}Bi_{0.3}O_{2-\delta}$ *solid solutions at 150 K ; (a) Derivative spectra (b) Integrated spectra*

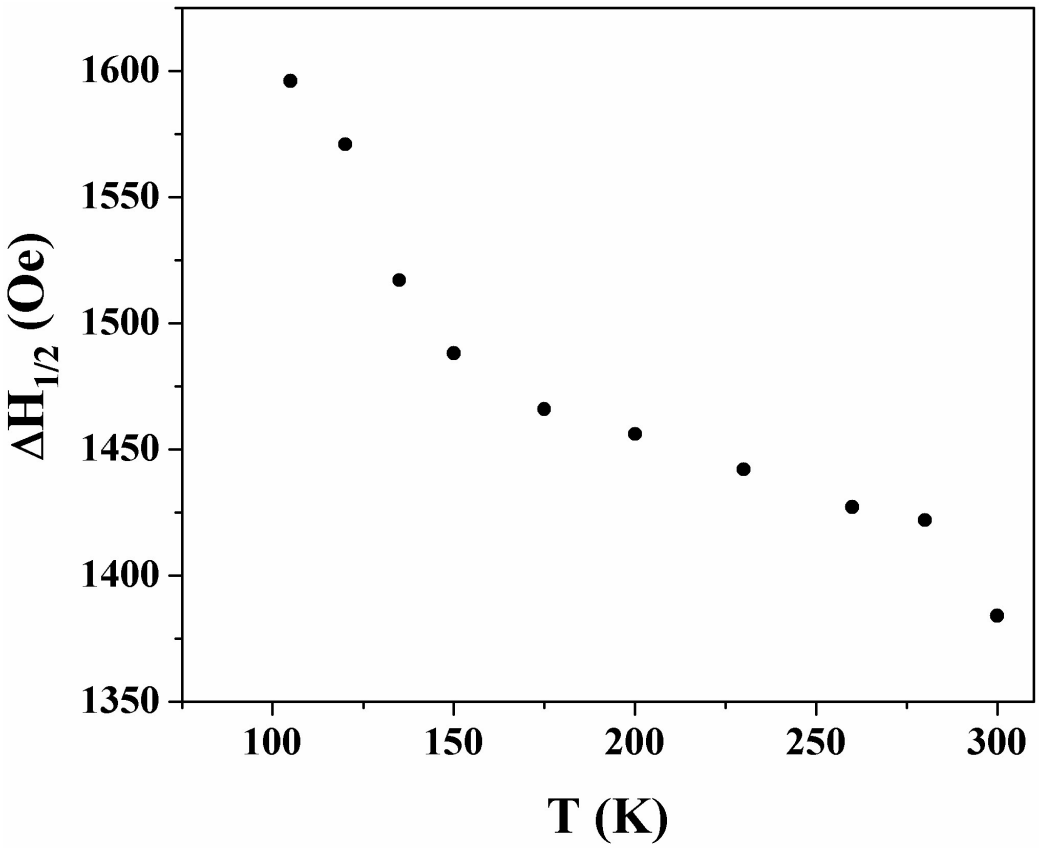

Figure S11: Temperature dependencies of line width, $\Delta H_{1/2}$, of the FMR signal of $Th_{0.7}Bi_{0.3}O_{2-\delta}$ *solid solutions*.

Table-S1:

Comparison of expected and XPS determined oxygen at% in $Th_{1-x}Bi_xO_{2-\delta}$

Solid Solutions	Expected O at% *	XPS determined O at%	% deviation of XPS value from the expected value
$Th_{0.9}Bi_{0.1}O_{2-\delta}$	66.1	67.6	-2.2
$Th_{0.8}Bi_{0.2}O_{2-\delta}$	65.5	63.1	3.9
$Th_{0.7}Bi_{0.3}O_{2-\delta}$	64.9	62.4	3.9

*: Calculated on the basis of preparation