

Supplementary Information to

“Synthesis and characterisation of a quaternary nitride series with spin-glass behaviour: $\text{Sn}_x\text{Ge}_{1-x}\text{Fe}_3\text{N}$ ”

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Supporting Figures:

X-ray diffraction pattern:

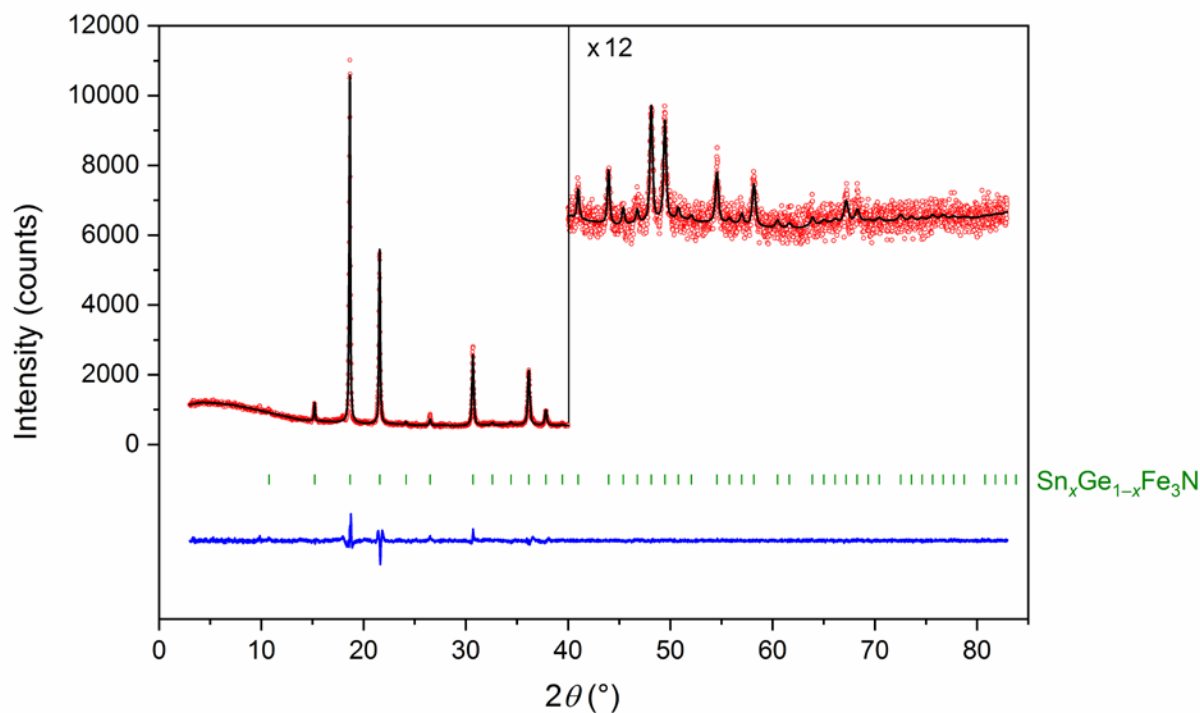


Figure S1: X-ray diffraction pattern measured with Mo $K\alpha_1$ radiation and Rietveld refinement of the quaternary nitride $^{1a}(\text{Sn}_{0.040(2)}\text{Ge}_{0.960(2)})^{3c}(\text{Fe}_3)^{1b}(\text{N})$ in space group $Pm\bar{3}m$ ($a = 3.7935(1)$ Å, $R_B = 4.62\%$).

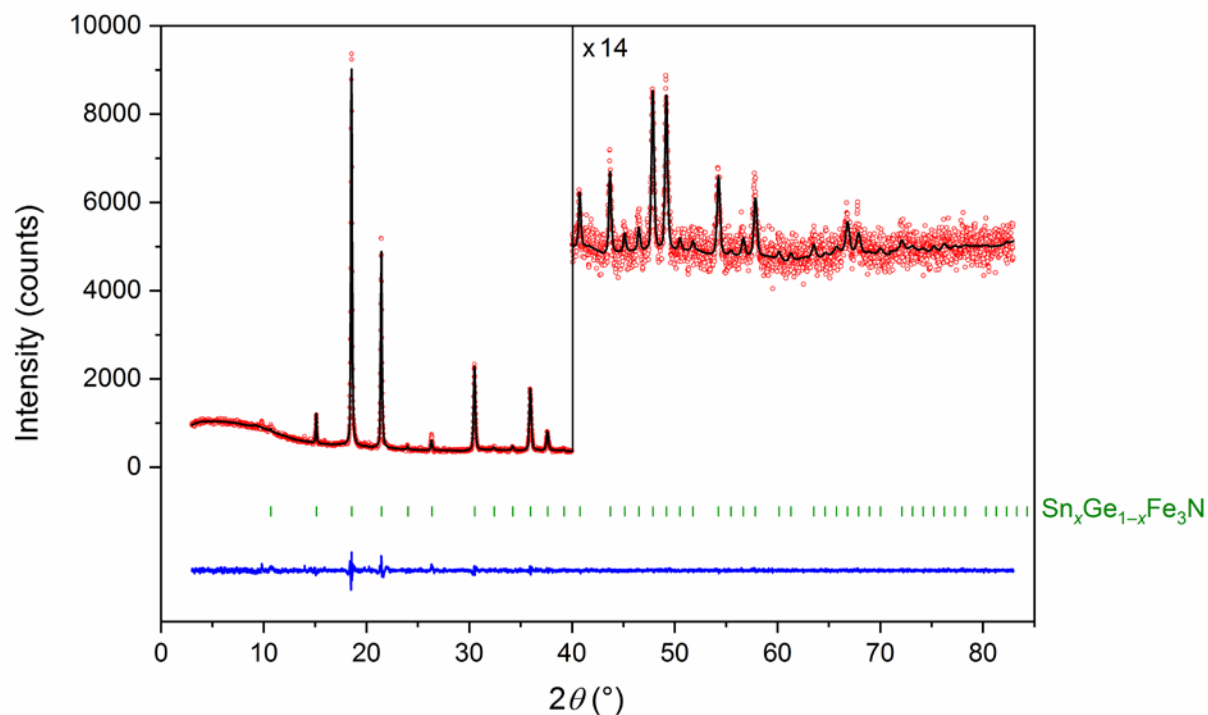


Figure S2: X-ray diffraction pattern measured with Mo $K\alpha_1$ radiation and Rietveld refinement of the quaternary nitride ${}^1a(\text{Sn}_{0.190(2)}\text{Ge}_{0.810(2)}){}^3c(\text{Fe}_3)1b(\text{N})$ in space group $Pm\bar{3}m$ ($a = 3.8122(1)$ Å, $R_B = 3.46\%$).

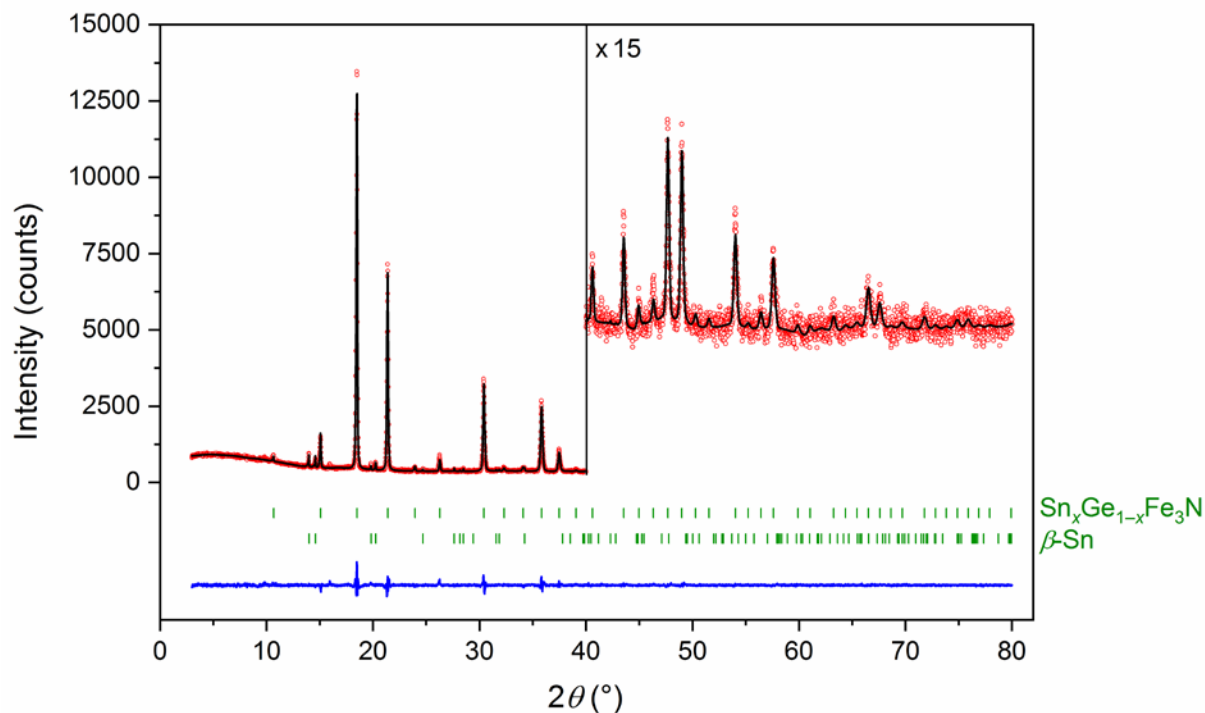


Figure S3: X-ray diffraction pattern measured with Mo $K\alpha_1$ radiation and Rietveld refinement of the quaternary nitride ${}^1a(\text{Sn}_{0.34(1)}\text{Ge}_{0.63(1)}\text{Fe}_{0.03(1)}){}^3c(\text{Fe}_3)1b(\text{N})$ in space group $Pm\bar{3}m$ ($a = 3.8273(1)$ Å, $R_B = 2.76\%$) with 4% of a tin side phase.

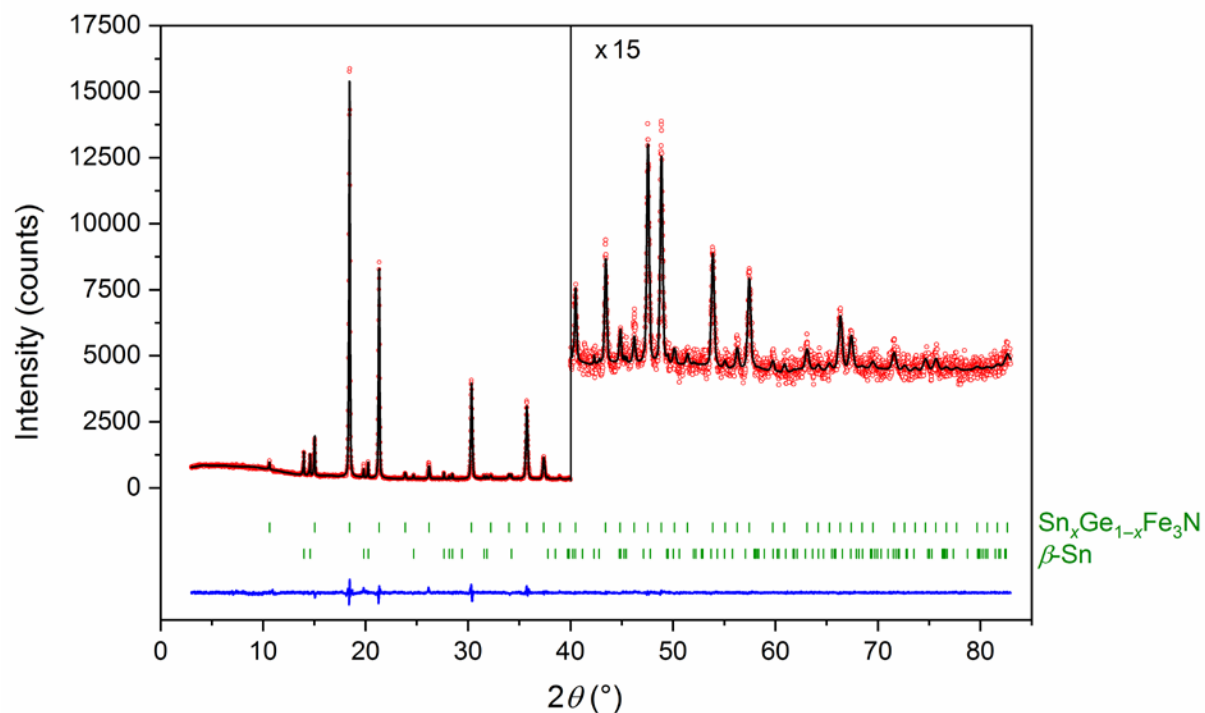


Figure S4: X-ray diffraction pattern measured with Mo $K\alpha_1$ radiation and Rietveld refinement of the quaternary nitride $^{1a}(\text{Sn}_{0.43(1)}\text{Ge}_{0.51(1)}\text{Fe}_{0.06(1)})^{3c}(\text{Fe}_3)^{1b}(\text{N})$ in space group $Pm\bar{3}m$ ($a = 3.8371(1)$ Å, $R_B = 2.74\%$) with 8% of a tin side phase.

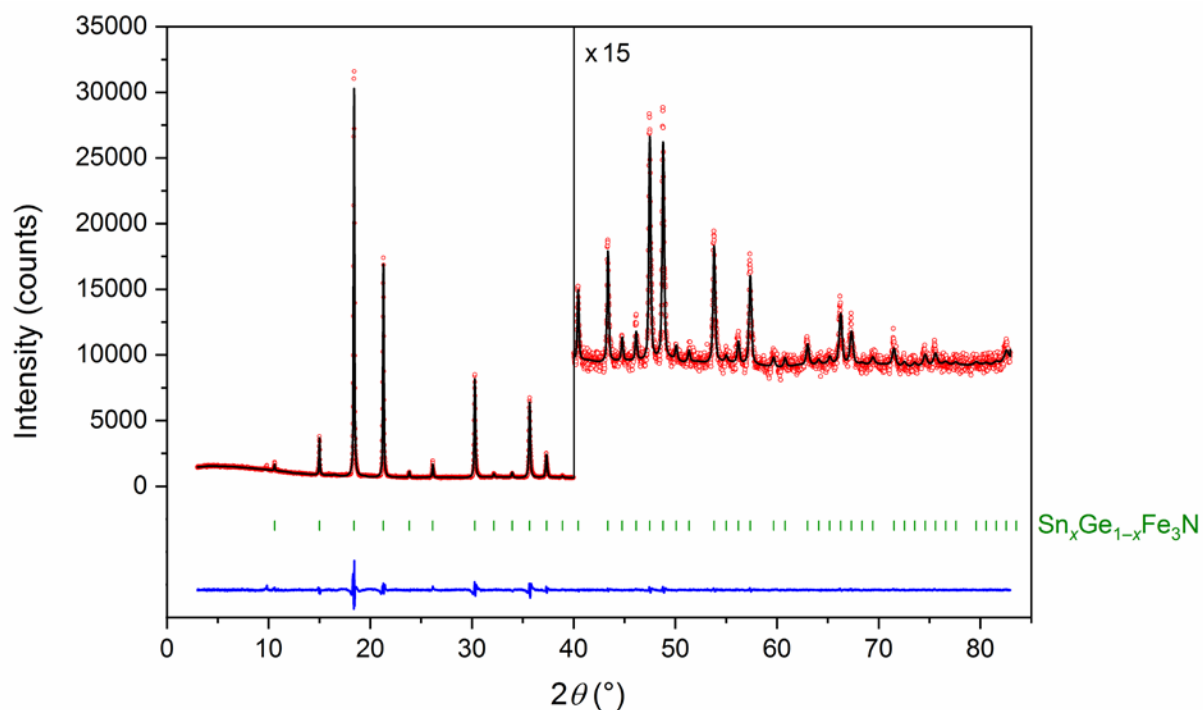


Figure S5: X-ray diffraction pattern measured with Mo $K\alpha_1$ radiation and Rietveld refinement of the quaternary nitride $^{1a}(\text{Sn}_{0.44(1)}\text{Ge}_{0.52(1)}\text{Fe}_{0.04(1)})^{3c}(\text{Fe}_3)^{1b}(\text{N})$ in space group $Pm\bar{3}m$ ($a = 3.8391(1)$ Å, $R_B = 2.56\%$).

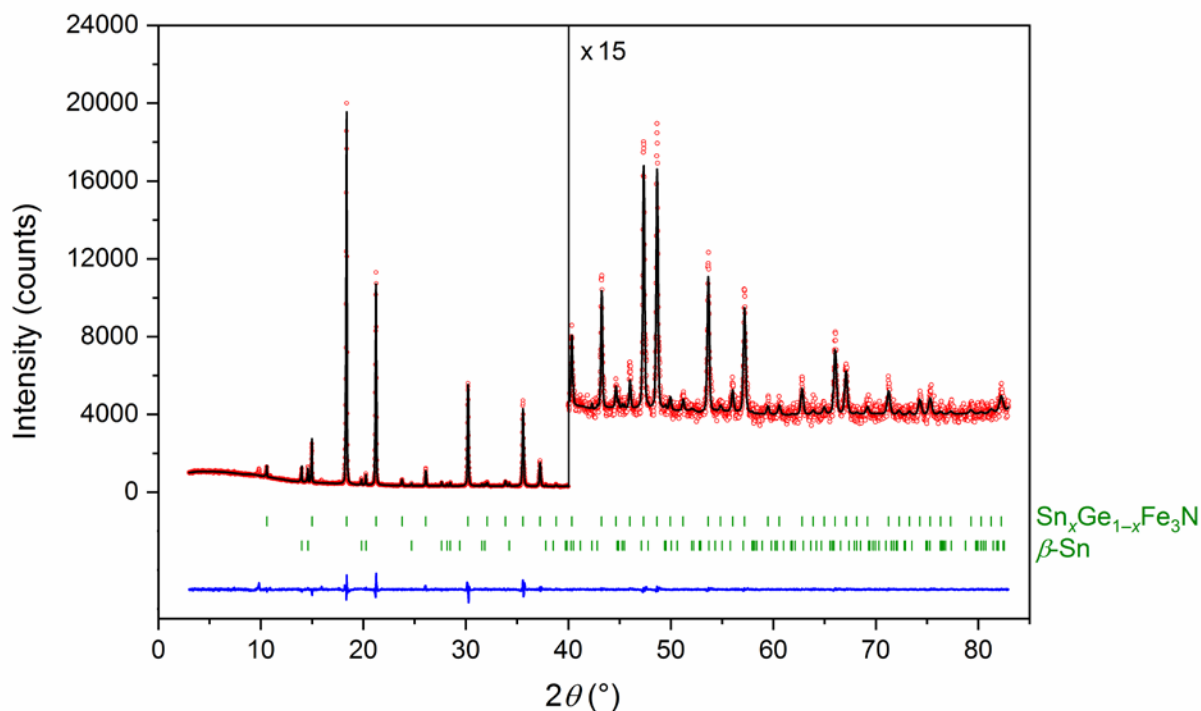


Figure S6: X-ray diffraction pattern measured with Mo $K\alpha_1$ radiation and Rietveld refinement of the quaternary nitride $^{1a}(\text{Sn}_{0.57(1)}\text{Ge}_{0.38(1)}\text{Fe}_{0.05(1)})^{3c}(\text{Fe}_3)^{1b}(\text{N})$ in space group $Pm\bar{3}m$ ($a = 3.8528(1)$ Å, $R_B = 2.75\%$) with 7% of a tin side phase.

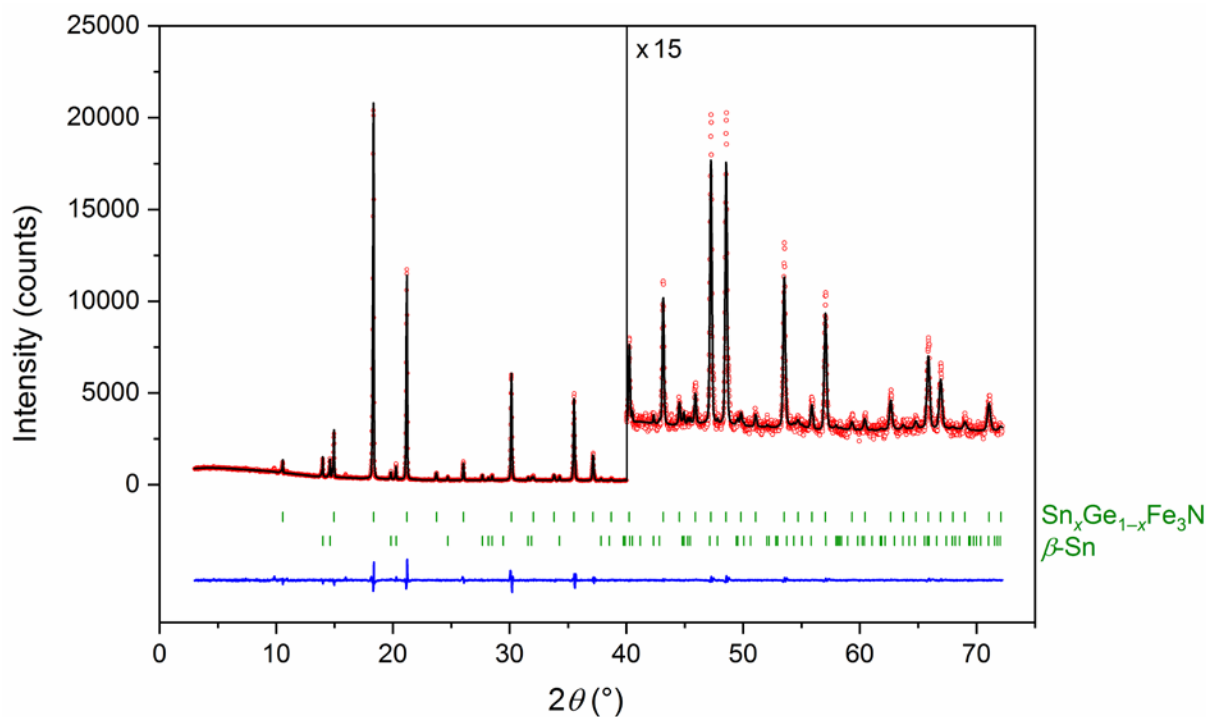


Figure S7: X-ray diffraction pattern measured with Mo $K\alpha_1$ radiation and Rietveld refinement of the quaternary nitride $^{1a}(\text{Sn}_{0.66(1)}\text{Ge}_{0.26(1)}\text{Fe}_{0.08(1)})^{3c}(\text{Fe}_3)^{1b}(\text{N})$ in space group $Pm\bar{3}m$ ($a = 3.8614(1)$ Å, $R_B = 2.60\%$) with 9% of a tin side phase.

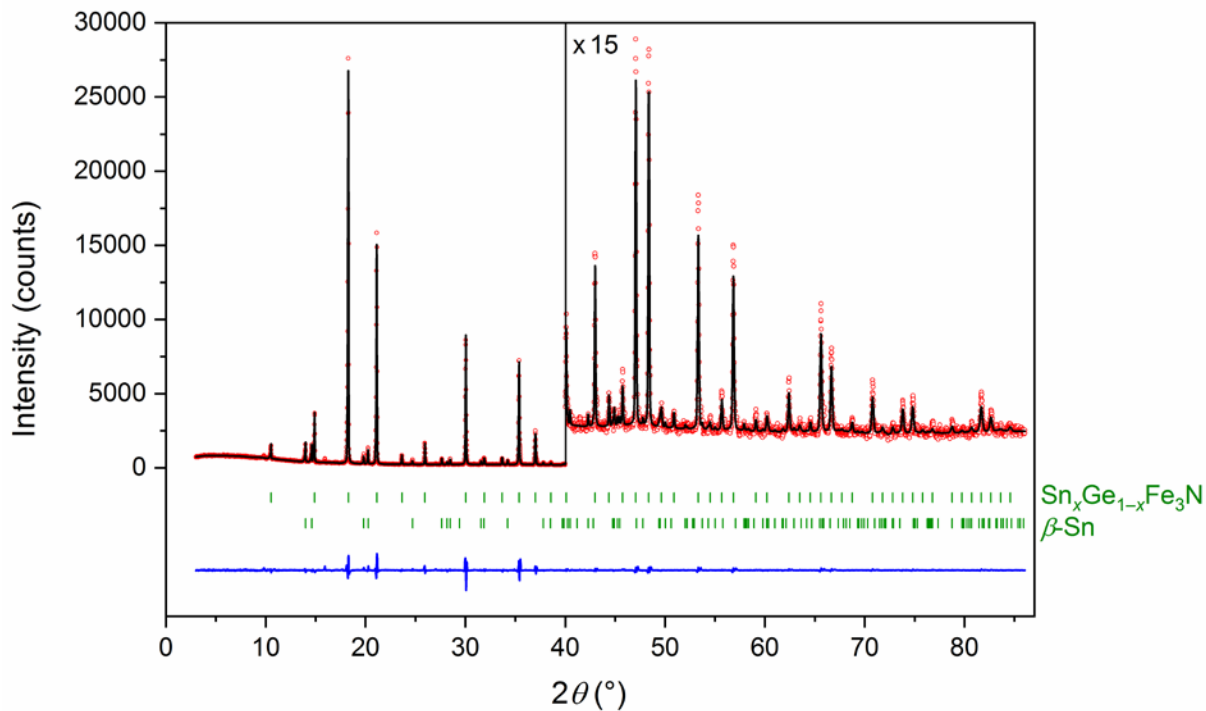


Figure S8: X-ray diffraction pattern measured with Mo $K\alpha_1$ radiation and Rietveld refinement of the quaternary nitride $^{1a}(\text{Sn}_{0.85(1)}\text{Ge}_{0.05(1)}\text{Fe}_{0.10(1)})^{3c}(\text{Fe}_3)^{1b}(\text{N})$ in space group $Pm\bar{3}m$ ($a = 3.8834(1)$ Å, $R_B = 4.88\%$) with 12% of a tin side phase.

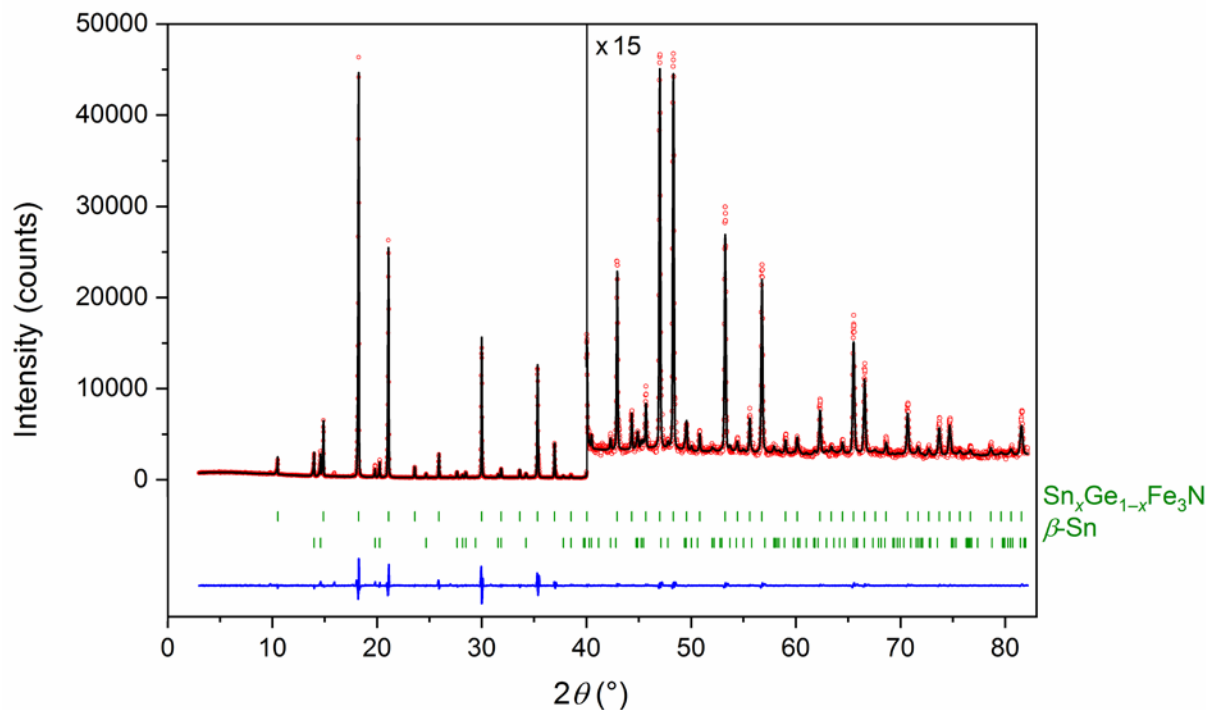


Figure S9: X-ray diffraction pattern measured with Mo $K\alpha_1$ radiation and Rietveld refinement of the quaternary nitride $^{1a}(\text{Sn}_{0.82(1)}\text{Ge}_{0.08(1)}\text{Fe}_{0.10(1)})^{3c}(\text{Fe}_3)^{1b}(\text{N})$ in space group $Pm\bar{3}m$ ($a = 3.8792(1)$ Å, $R_B = 3.52\%$) with 12% of a tin side phase.

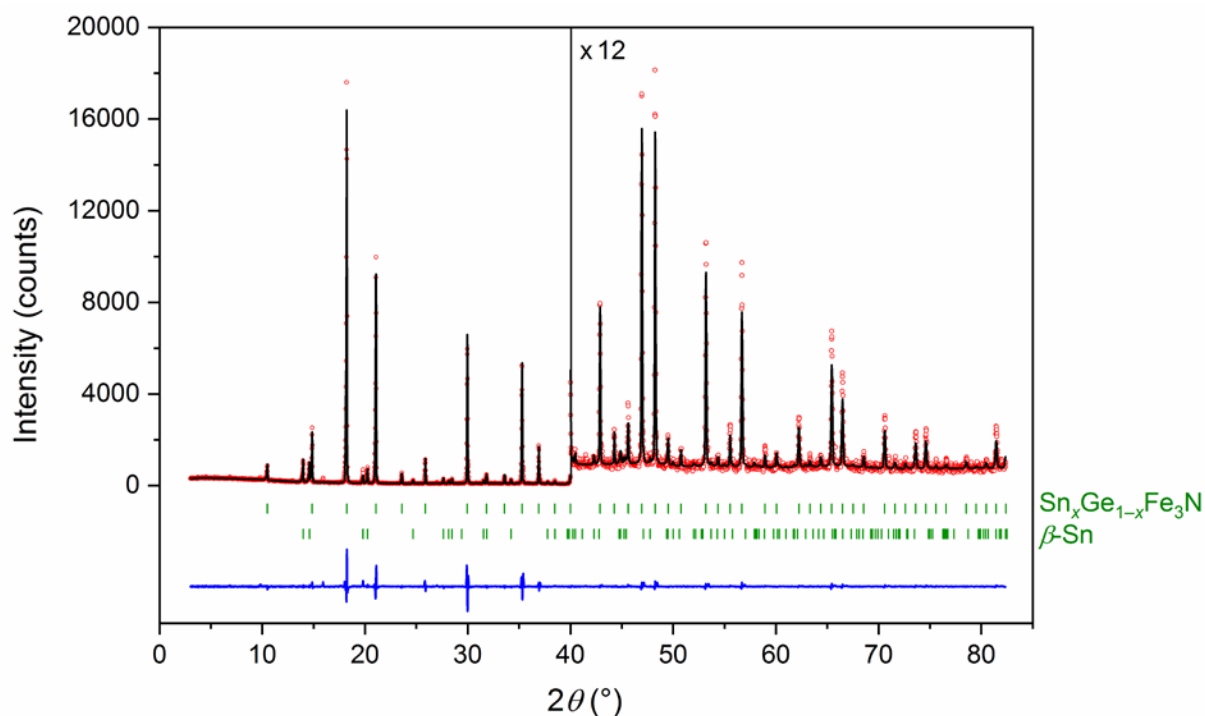


Figure S10: X-ray diffraction pattern measured with Mo $K\alpha_1$ radiation and Rietveld refinement of the quaternary nitride $^{1a}(\text{Sn}_{0.82(1)}\text{Ge}_{0.08(1)}\text{Fe}_{0.10(1)})^{3c}(\text{Fe}_3)^{1b}(\text{N})$ in space group $Pm\bar{3}m$ ($a = 3.8792(1)$ Å, $R_B = 3.52\%$) with 12% of a tin side phase.

Magnetic measurements:

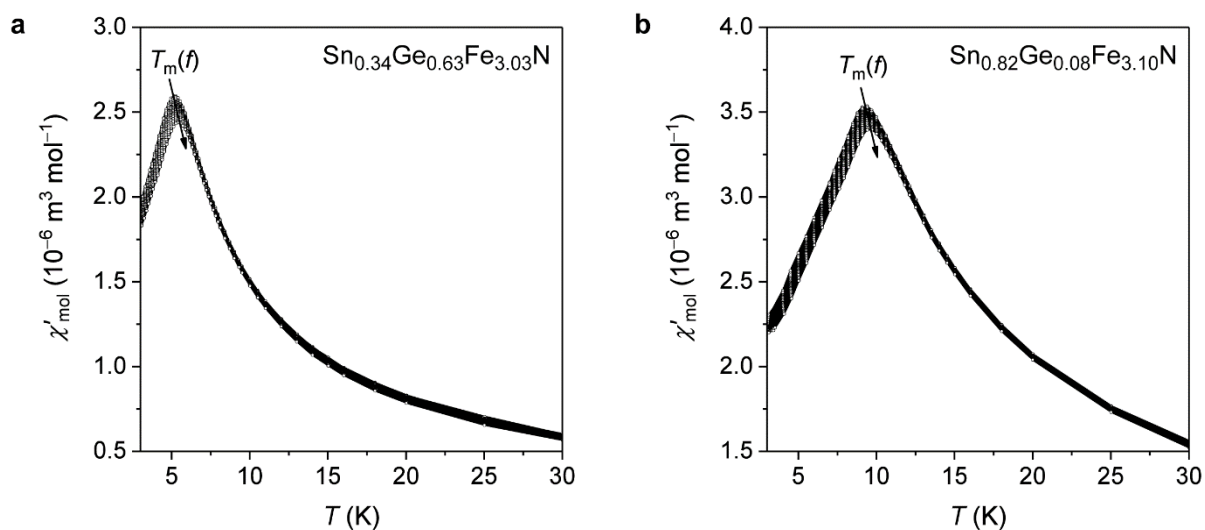


Figure S11: a and b Confirmation of the spin-glass behaviour for two quaternary nitrides $\text{Sn}_x\text{Ge}_{1-x}\text{Fe}_3\text{N}$: Temperature dependence of the real part of the molar AC susceptibility χ'_m , measured in a frequency range $84 \leq f \leq 10000$ Hz. The peak temperature T_m of the χ'_m maximum depends on the frequency.

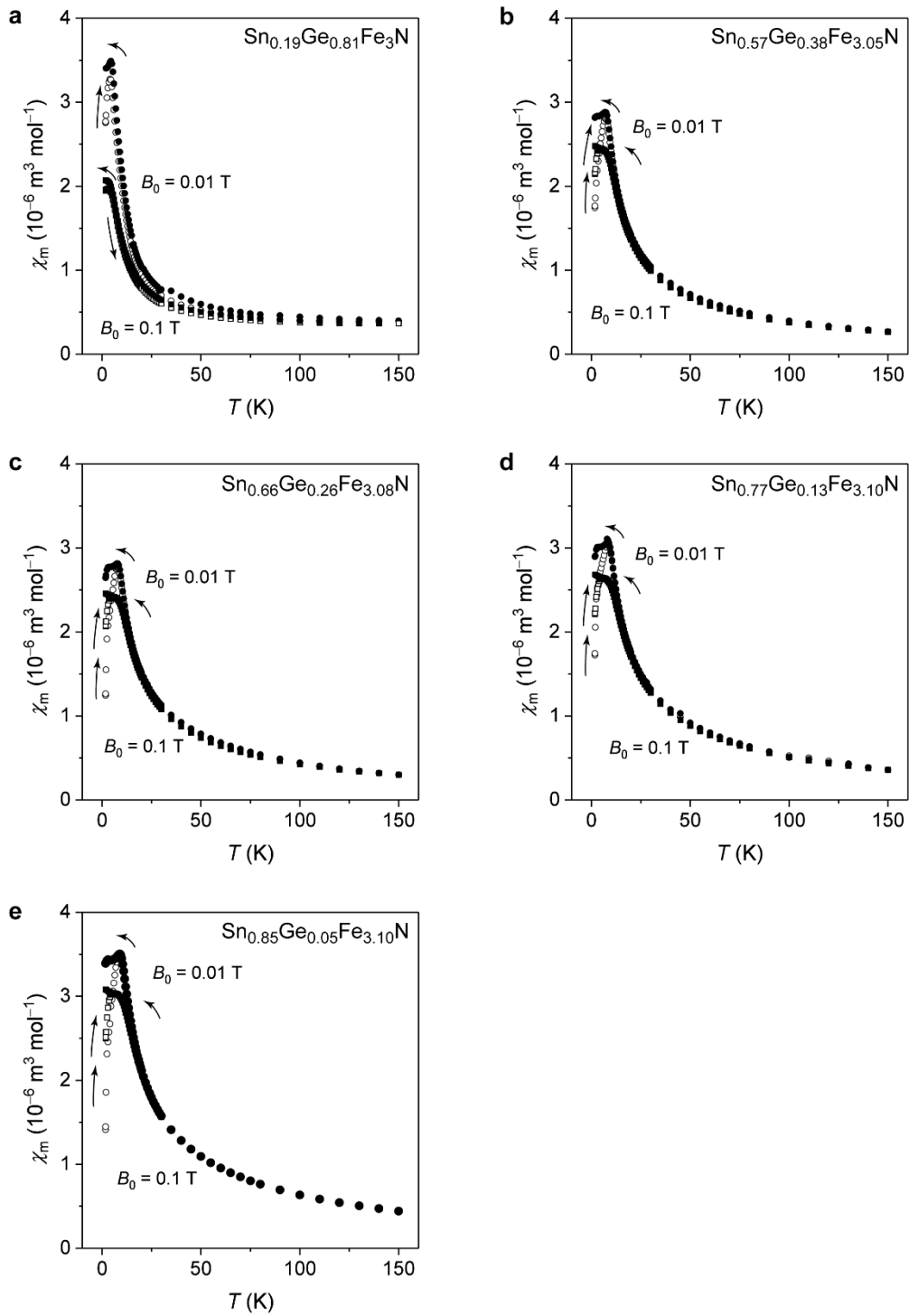


Figure S12: a–e Molar FC (filled symbols) and ZFC (empty symbols) DC susceptibilities for different quaternary nitrides $\text{Sn}_x\text{Ge}_{1-x}\text{Fe}_3\text{N}$ as a function of temperature under probing fields $B_0 = 0.01 \text{ T}$ and 0.1 T . The susceptibilities show maxima at low temperatures T_m , that characterize the magnetic transitions (T_g). The FC and ZFC curves diverge below T_m , a fingerprint of the spin-glass behaviour in these compounds.