Electronic Supplementary Material (ESI) for ChemComm.

Supplementary Information

Dilute but significant: Low cation concentration affects field dependent properties of $Eu_2Ga_{11}Sn_{35}$

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Material Characterization

Single crystals of $Eu_2Ga_{11}Sn_{35}$ were obtained using the synthesis method previously reported [1]. Table S1 provides the single crystal structure refinement results. The crystallographic data for $Eu_2Ga_{11}Sn_{35}$ is available from the Cambridge Crystallographic Database under CCDC 2154399. The stoichiometry of the composition was further analyzed by a JEOL JSM-6390LV Scanning Electron Microscope (SEM) equipped with an Oxford INCA X-Sight 7852 for Energy Dispersive Spectroscopy (EDS) corroborating the single crystal X-ray diffraction results. The homogeneity of the obtained crystals was confirmed by EDS elemental mapping of several crystal surfaces as shown in Figure S1.

Temperature and Field Dependent Magnetic, Electrical and Thermal Properties Measurements

The Dynacool Physical Property Measurement System (PPMS) from Quantum Design was used for temperature and field dependent measurements from 300 K to 2 K. The Vibrating Sample Magnetometer (VSM) module, resistivity module, Thermal Transport Option (TTO) module and Heat Capacity (HC) module were used to measure the field dependent magnetization, M, temperature dependent magnetic susceptibility, χ, Hall coefficient, R_h, the thermal conductivity, κ, thermopower, α, electrical resistivity, ρ, and the isobaric heat capacity, C_p, respectively. The magnetization of the specimen was measured at 1.8 K, 3.5 K, 5 K, 10 K and 300 K from -7 T to 7 T. Zero field cooled (ZFC) and field cooled (FC) χ was measured under an applied magnetic field of 9 T from 1.8 K to 250 K, as shown in Figure S2. The ρ and κ measurements were performed at 0T, 6.75 T and 9 T from 300 K to 5 K in a two-probe configuration under continuous sweep mode at a rate of 0.5 K/min. The crystal was attached to the TTO module using Au coated manganin leads using Ag epoxy (H20E). Temperature-dependent C_p was measured at 0 T and 9 T employing the heat capacity option (HC) of the PPMS. Thermal N-grease was used to couple the crystal with the mounting stage of the HC module. The measurements were performed with a 2% temperature rise. The two-tau model of the Quantum Design heat capacity software was used for the measurements. Appropriate addendum measurements preceded the heat capacity measurements. Maximum experimental uncertainties of 7%, 5%, 5% and 3% were calculated for κ, α, ρ, and C_p, respectively.

Table S1. Crystal data and structure refinement data.

Empirical formula	$Eu_{2.2(2)}Ga_{11.0(2)}Sn_{35.0(2)}$
Formula weight	5258.42
Temperature/K	298 K
Crystal system, Space group	cubic, $Pm\bar{3}n$
a/Å, Volume/Å^3	11.9497(5), 1706.4(7)
Z, ρ_{calc}/g cm^{-3}	1, 5.117
μ/mm^{-1}, F(000)	18.020, 2231
Crystal size/mm^3	0.12 x 0.11 x 0.06
Radiation, 2Θ range for data collection/°	Synchrotron (λ = 0.41328 Å), 2.0 to 31.14
Index ranges	$-15 \leq h \leq 15$, $-15 \leq k \leq 15$, $-15 \leq l \leq 15$
Reflections collected, Independent reflections	39436, 380 [R_{int} = 0.0646, R_{sigma} = 0.0098]
Data/restraints/parameters	380/1/21
Goodness-of-fit on F^2, Final R indexes [I>=4σ (I)]	1.225, R1 = 0.0095, wR2 = 0.0216
Largest diff. peak/hole / e Å^{-3}	0.55/-0.36

$R_1 = \Sigma||F_o|-|F_c||/\Sigma|F_o|$, $wR_2 = [\Sigma w(F_o^2-F_c^2)^2/\Sigma w(F_o^2)^2]^{1/2}$

* U_{eq} is defined as one third of the trace of the orthogonalized U_{ij} tensor.

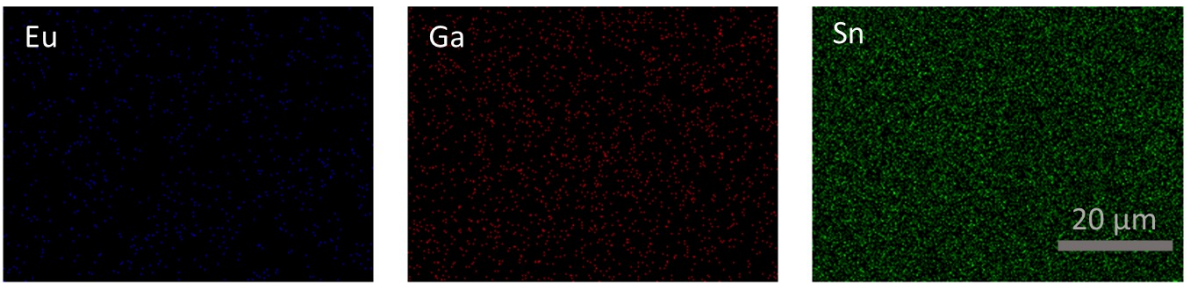

Figure S1. EDS elemental mapping of a surface of a representative crystal of $Eu_2Ga_{11}Sn_{35}$.

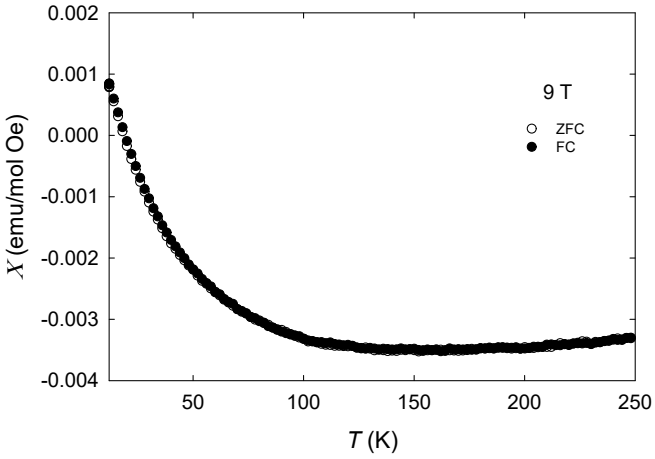

Figure S2. Zero field cooled and field cooled χ.

References

1 W. D. C. B. Gunatilleke, W. Wong-Ng, P. Y. Zavalij, M. Zhang, Y.-S. Chen and G. S. Nolas, *CrystEngComm*, 2023, **25**, 48–52.