Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supplemental Information for "Combinatorial Insights into Doping Control and Transport Properties of Zinc Tin Nitride"

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Fig. S1 shows conductivity as a function of growth temperature for Zn-rich films with cation composition of 0.60 Zn/(Zn+Sn). Conductivity of Zn-rich films varied by more than an order of magnitude as a function of increasing growth temperature; from 0.1–5.5 S cm^{-1}. This variation of conductivity with temperature was not as pronounced as for variation with composition (Fig. 2a) for a fixed growth temperature. The critical temperature at which the conductivity trend switched from decreasing to increasing was found to be 120°C.

Fig. S2 shows a transmission electron diffraction (TED) pattern from a nominally stoichiometric film grown at 300°C with the six smallest diffraction rings numbered in white (left panel), and a corresponding table giving the calculated lattice spacing from each ring (right panel). The experimental lattice spacing values were found to be consistent with a wurtzite lattice. These values are also consistent with lattice parameters calculated previously for cation-disordered $ZnSnN_2$, in which the c-axis lattice parameter was 5.53 Å and the a-axis parameter was 3.38 Å.[1]

Fig. S3 shows the results of temperature-dependent Hall effect performed on a stoichiometric (Zn/(Zn+Sn) = 0.50) and zinc-rich (Zn/(Zn+Sn) = 0.60) film grown at 230°C, respectively. No significant temperature dependence was observed in the carrier density or

mobility shown in panel (a), and neither for conductivity shown in panel (b). Considering the relatively low carrier density observed in zinc-rich films, these results support the existence of a large density of competing *n*-type and *p*-type defects combining to yield the ultimate *n*-type carrier density observed.

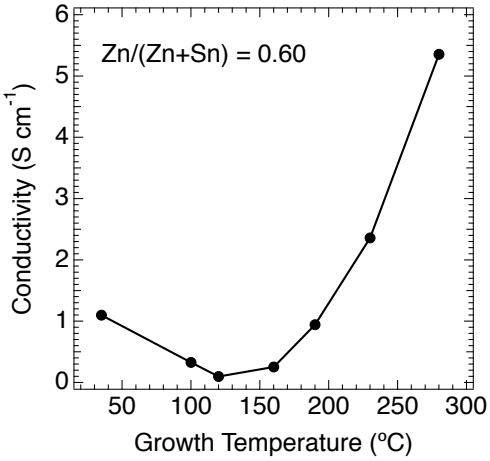
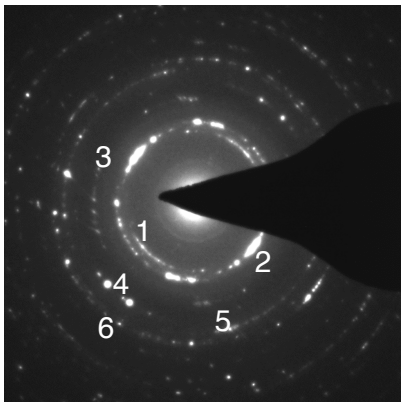


Fig. S1: Conductivity as determined by 4-point probe paired with thickness measurements, shown as a function of growth temperature for Zn-rich films with 0.60 Zn/(Zn+Sn). Conductivity decreases until 120°C, after which the conductivity increases again. The overall change in conductivity was more than an order of magnitude.



Diffraction Ring	Lattice Spacing (Å)
1	2.97
2	2.77
3	2.58
4	2.02
5	1.70
6	1.56

Fig. S2: TED pattern taken from a nominally stoichiometric film grown at 300°C (left) with the six smallest diffraction rings numbered in white. A table giving the corresponding lattice spacing for each diffraction ring is shown on the right. These lattice spacing values are consistent with a wurtzite lattice for $ZnSnN_2$.

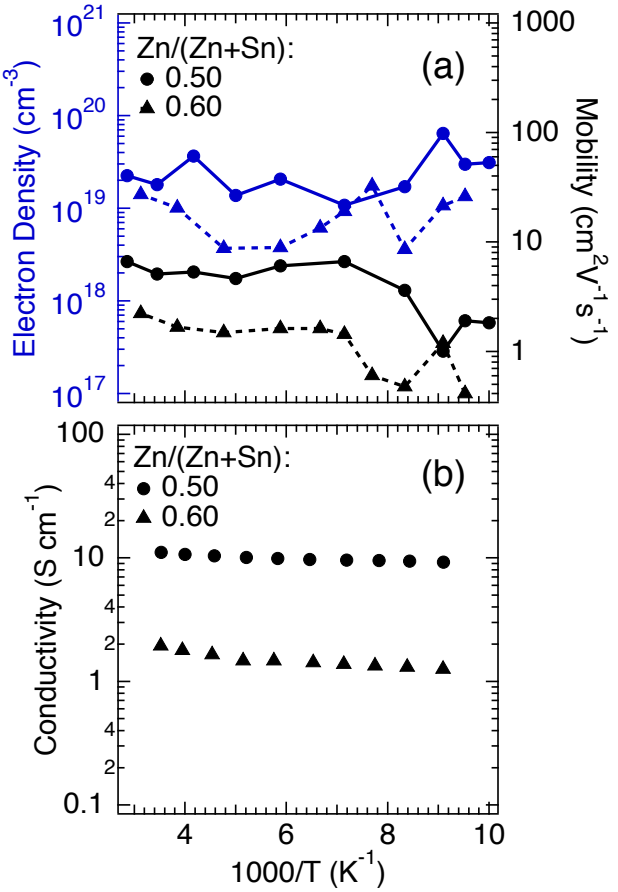


Fig. S3: Temperature-dependent Hall effect data taken from a stoichiometric (0.50) and zinc-rich (0.60) Zn-Sn-N film, respectively. No significant temperature dependence was observed in the carrier density or mobility (a), and neither for conductivity (b). These results support the existence of a large density of competing *n*-type and *p*-type defects combining to yield the ultimate *n*-type carrier density

REFERENCES

[1] Feldberg, N. *et al.* Growth, disorder, and physical properties of $ZnSnN_2$. *Applied Physics Letters* 103 (2013).