# The Rb-Sn (Rubidium-Tin) System

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## Equilibrium Diagram

The assessed Rb-Sn phase diagram is given in Fig. 1, and the special points of this diagram are listed in Table 1. Phase diagram data were obtained by thermal analysis [81Dri]; the liquidus data are given only as points on a phase diagram, from which they were read. Another small, unlabeled phase diagram is found in [78Chu2]; apart from the stated source of this diagram (A.N. Kuznetsov, Thesis, Sverdlovsk, 1978) no other information is given. Although the information from this report [78Chu2] is very meager and of unknown quality, it is apparent that the phase diagrams in [81Dri] and [78Chu2] represent independent investigations. Despite the sparseness of data in the earlier report [78Chu2], certain general features of the phase diagram may be extracted and are mentioned in the following evaluation.

There are two eutectics in this system, the temperatures of which are indistinguishable from the melting points of the pure elements [81Dri]. The eutectic compositions were assumed [81Dri] to be practically identical with the pure elements and zero solid solubility was also assumed. In the absence of any more specific information, these assumptions may be reasonable.

There is a region of liquid immiscibility [78Chu2, 81Dri] in this system, and the monotectic temperature was reported to be 610 °C [81Dri]. The miscibility gap at this temperature is given as 15 to 42 at.% Sn in [81Dri] and about 5 to 41 at.% Sn in [78Chu2]. In the assessed phase diagram, Fig. 1, the wider miscibility gap is shown; this was done to have the Rb-Sn diagram conform closely to that of the Cs-Sn system, which is quite similar in other aspects.

Both investigators [78Chu2, 81Dri] agree on the number and stoichiometry of intermetallic compounds. RbSn was prepared by direct reaction of the elements [64Hew] and melts incongruently at 570 °C [81Dri]. The earlier work suggests that RbSn might melt congruently at a much higher temperature [78Chu2] but this is contradicted by the later study [81Dri]. It was characterized by its powder XRD pattern [64Hew].

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**Table 1 Special Points of the Assessed Rb-Sn Phase Diagram**

| Reaction | Composition of the respective phases, at.% Sn | | | Temperature, °C | Reaction type |
|---|---|---|---|---|---|
| L ↔ (Rb) | | 0 | | 39.48 | Melting point |
| L ↔ (Rb) + RbSn | ~0 | 0 | 50.0 | ~39.5 | Eutectic |
| L ↔ L + RbSn | ~2.5 | 41.0 | 60.0 | 610 | Monotectic |
| L + $Rb_2Sn_3$ ↔ RbSn | ~2.0 | 60.0 | 50.0 | 570 | Peritectic |
| L ↔ $Rb_2Sn_3$ | | 60.0 | | 890 | Congruent point |
| L + $Rb_2Sn_3$ ↔ $RbSn_2$ | 75.0 | 60.0 | 66.7 | 830 | Peritectic |
| L + $RbSn_2$ ↔ $RbSn_4$ | 95.5 | 66.7 | 80.0 | 507 | Peritectic |
| L ↔ $RbSn_4$ + (Sn) | ~100 | 80.0 | 100 | ~232 | Eutectic |
| L ↔ (βSn) | | 100 | | 231.9681 | … |

**Table 2 Rb-Sn Crystal Structure and Lattice Parameter Data at 25 °C**

| Phase | Composition, at.% Sn | Pearson symbol | Space group | Strukturbericht designation | Prototype | Lattice parameters, nm *a* | *c* | Reference |
|---|---|---|---|---|---|---|---|---|
| (Rb) | 0 | *cI*2 | $Im\bar{3}m$ | *A*2 | W | 0.5705 | … | [Massalski2] |
| RbSn | 50 | *tI*64 | $I4_1/acd$ | … | NaPb | 1.171 | 1.909 | [64Hew] |
| (αSn)(a) | 100 | *cF*8 | $Fd\bar{3}m$ | *A*4 | C | 0.64892 | … | [Massalski2] |
| (βSn) | 100 | *tI*4 | $I4_1/amd$ | *A*5 | βSn | 0.58318 | 0.31818 | [Massalski2] |

**(a)** <18 °C.

$Rb_2Sn_3$ melts congruently at 890 °C [81Dri], which is the highest temperature on the Rb-Sn liquidus. $RbSn_2$ melts incongruently at 830 °C with a peritectic liquid composition of 75 at.% Sn [81Dri]. $RbSn_4$ also melts incongruently, at 507 °C and a peritectic liquid composition of 95.5 at.% Sn [81Dri]. It is possible that the most Sn-rich compound has the stoichiometry $Rb_8Sn_{46}$ rather than $RbSn_4$, because in the K-Sn and Cs-Sn systems both $KSn_4$ and $CsSn_4$ were shown to be more correctly

$K_8Sn_{46}$ and $Cs_8Sn_{46}$ on the basis of single crystal x-ray analyses. The Rb-rich compounds $Rb_4Sn$ and $Rb_2Sn$ were suggested as "possible" compounds in this system [80Guk], but the x-ray

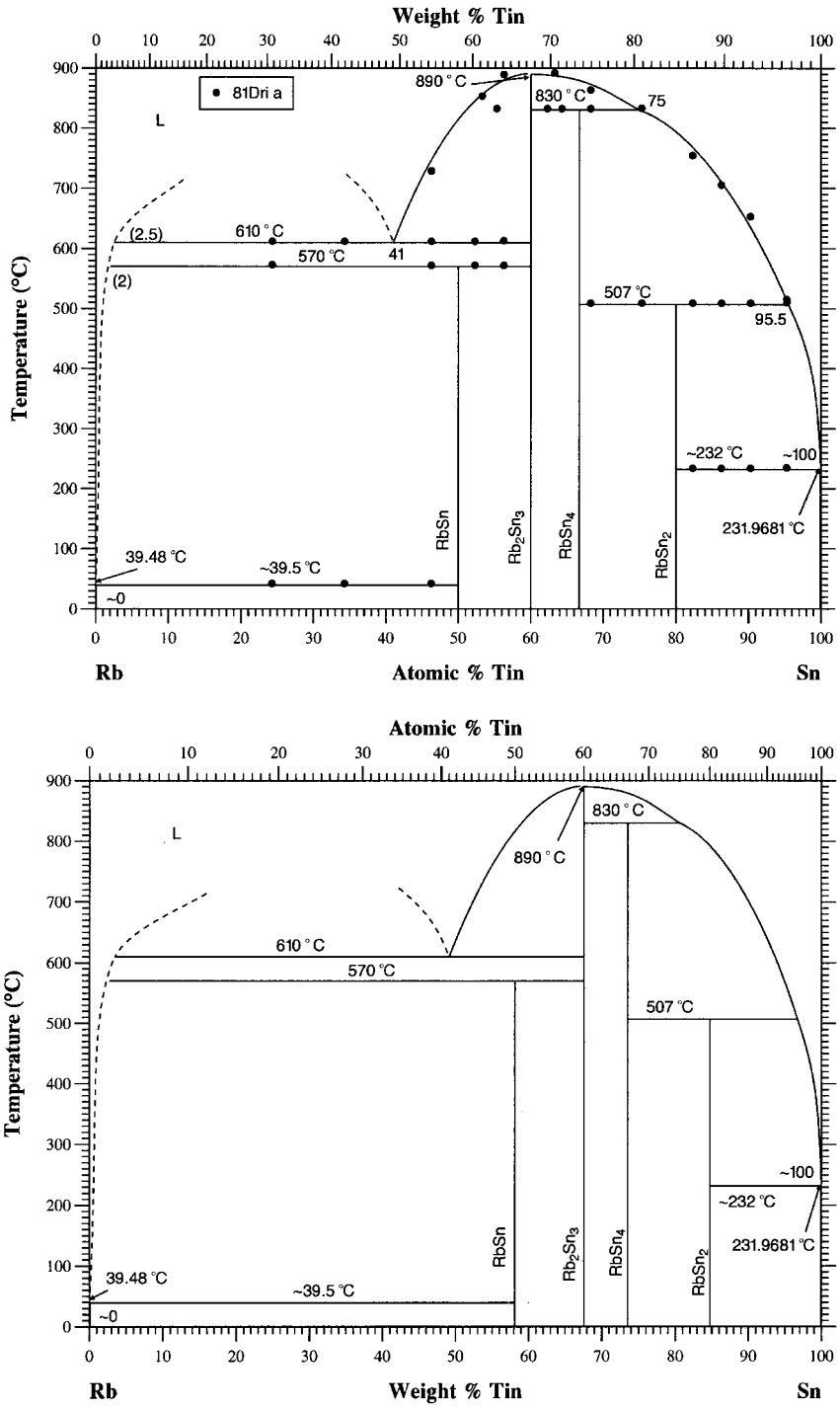


**Fig. 1** Assessed Rb-Sn phase diagram.

"photogram" evidence is very meager, and no thermal arrests that might correspond to these compounds were observed in the Rb-RbSn composition range [78Chu2, 81Dri].

## Crystal Structures and Lattice Parameters

The crystal data are summarized in Table 2. RbSn is isostructural with KSn and CsSn, being body-centered tetragonal with $Sn_4$ tetrahedral groups [64Hew]. The structures of the other compounds in this system have not been elucidated.

## Thermodynamics

The standard enthalpy of formation of RbSn, as determined from direct reaction calorimetry, was reported to be –38.9 kJ/g-atom [78Chu1].

### Cited References

**64Hew:** I.F. Hewaidy, E. Busmann, and W. Klemm, "Structures of the AB Compounds of the Heavy Alkali Metals with Sn and Pb," *Z. Anorg. Allg. Chem.*, *328*(5-6), 283-293 (1964) in German. (Equi Diagram, Crys Structure; Experimental)

**78Chu1:** K.A. Chuntonov, S.P. Yatsenko, and V.D. Bushmanov, "Heats of Formation of Equiatomic Compounds of Rb with Group IV Non-transition Elements," *Zh. Fiz. Khim*, *52*(6), 1554 (1978) in Russian; TR: *Russ. J. Phys. Chem. (Engl. Transl.)*, *52*(6), 902 (1978). (Thermo, Experimental)

**78Chu2:** K.A. Chuntonov and S.P. Yatsenko, "Immiscibility in Molten Binary Alloys of Rb with p-Elements," *Zh. Fiz. Khim.*, *52*(9), 2145-2154 (1978) in Russian; TR: *Russ. J. Phys. Chem. (Engl. Transl.)*, *52*(9), 1241-1247 (1978). (Equi Diagram, Review; #).

**80Guk:** Yu.Ya. Gukova and O.Ya. Gukov, "Possible Compounds in the K-Sn and Rb-Sn Systems," Deposited Document SPSTL 778 Khp-D80, 4 pages (1980) in Russian. (Equi Diagram; Experimental)

**81Dri:** M.E. Drits, A.S. Fridman, L.L. Zusman, and V.A. Kusikov, "Phase Diagram of Sn with K, Rb and Cs," *Fazovye Ravnovesiya Met. Splavakh*, 176-178 (1981) in Russian. (Equi Diagram; Experimental; #)

# Indicates presence of a phase diagram.

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