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J. Petersen, S. Damgaard, G. Weyer, Jacques Chevallier, H. Nielsen. IMPURITY-DEFECT STRUCTURES OF Sn, Sb AND Te IMPLANTED α -TIN SINGLE CRYSTALS. Journal de Physique Colloques, 1980, 41 (C1), pp.C1-443-C1-444. 10.1051/jphyscol:19801172 . jpa-00219660

HAL Id: jpa-00219660 https://hal.science/jpa-00219660

Submitted on 4 Feb 2008

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IMPURITY-DEFECT STRUCTURES OF Sn, Sb AND TE IMPLANTED Q+TIN SINGLE CRYSTALS

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1. Introduction

Mössbauer emission spectroscopy on the 24-keV γ -transition of ¹¹⁹Sn has been applied previously to study impurity defects in group-IV semiconductors from ion implantation of ^{119 m}Te [1]. Here we report on experiments with α -tin single crystals involving implantations of ^{119 m}Sn, ¹¹⁹Sb, and ^{119 m}Te,

2. Experimental procedure

The α -tin single crystals were grown from a tin-mercury alloy. The ^{119 m}Te activity was obtained from an irradiation of natural tin with 24 MeV – particles. The ^{119 m}Te(T_{1/2} = 4.7 d) was separated chemically from the tin target. ^{119 m}Te decays to ¹¹⁹Sb (T_{1/2} = 38 h) which in turn populates the Mössbauer level of ¹¹⁹Sn. The ¹¹⁹Sb activity was milked from the ^{119 m}Te. Implantations were performed at room temperature with an isotope separator at an energy of 80 keV. Doses of $\leq 10^{13}$ atoms/cm² were implanted for ^{119 m}Te and ¹¹⁹Sb and $5 \cdot 10^{14}$ atoms/cm² for ^{119 m}Sn. Mössbauer emission spectra were measured at source temperatures between 77 and 300 K with a resonance counter of the parallel plate avalanche type [2].

3. Experimental results and discussion

Spectra from implantations of ¹¹⁹ m_{Sn}, ¹¹⁹Sb, and ^{119m}Te in α -tin single crystals are displayed in Figure 1. The ^{119m}Sn spectrum has been decomposed into two emission lines (taking the known quadrupole splitting of the SnO₂ absorber material into account for each line) as indicated in the figure.



Figure 1 : Mössbauer spectra measured at source temperatures of 77 K for implantations of 119 Sn(a), 119 Sb(b), 119 Te(c) in α -tin single crystals.

Line 1 at $\delta_1 = 0.0$ mm/s is attributed to a minor fraction of ^{119 m}Sn implanted into the surface oxide layer of the sample. Line 2, $\delta_2 = 2.16(5)$ mm/s, stems from ^{119 m}Sn atoms on substitutional lattice sites. Compared to an absorption spectrum measured for the unimplanted single crystal sample, this line is slightly broadened by ~ 0.1 mm/s and shifted to a higher isomer shift value by ~ 0.1 mm/s. This is due 30 to the influence of unannealed radiation damage from the implantation. The Debye temperature of line 2 is determined to $\Theta_2 = 162(5)$ K from temperature-dependent measurements. This is in agreement with a value of $\Theta = 162(5)$ K for the undamaged material [3]. It should be mentioned that the shoulder on line 2 may indicate the presence of a weak third line at $\delta \approx 3.4$ mm/s in the spectrum.

The spectrum from the ¹¹⁹Sb implantation has been analysed in terms of three lines, a surface oxide line $\delta_1 = 0.0$ mm/s, a substitutional line at $\delta_2 = 2.1$ mm/s, and an additional line 3 at $\delta_3 =$ = 2.6(1) mm/s. This line is broadened by~ 0.3 mm/s compared to line 2 and has a lower Debye temperature, $\Theta_3 = 135(15)$ K. Analogous to conclusions drawn for a very similar line in silicon [4], this line is attributed to Sn atoms on (nearly) substitutional sites with one or two vacancies in the nearest neighbour shell. The change in the Mössbauer parameters compared to an undisturbed substitutional site can be explained by the presence of dangling bonds at the Sn atoms.

Most likely the same line (δ = 2.67(3), $\Delta E_Q^{}$ = 0.4(2) mm/s, Θ = 130(20) K) has been observed by Vogl and Vogl [5] for ^{119m}Sn produced by neutron irradiation of α -tin at low temperatures. This defect line annealed at ~120 K in accordance with the fact that the defect is not formed in room temperature implantations of ^{119m}Sn. However, the vacancy defect is more stable when associated with Sb, thus the same Sn-vacancy structure may exist after the decay of Sb for times longer than the lifetime (τ = 27 ns) of the Mössbauer level.

The spectrum for implanted ^{119 m}Te is decomposed into four lines. Three with parameters very close to those for lines 1-3 and an additional line at $\delta_4 = 3.9(1)$ mm/s. For polycrystalline α -Sn, which has a thicker surface oxide layer, this line was observed with much larger intensity [1]. This is in agreement with a tentative assignment of this line to an oxygen-containing defect structure.

4. Conclusions

Different ¹¹⁹Sn defect structures have been obtained from implantations of ^{119^m}Te, ¹¹⁹Sb, and ^{119^m}Sn in α -tin single crystals. Implantations of ^{119^m}Sn result in no specific defect line, however, the spectra are influenced by radiation damage and, due to the high implanted dose, the material may be amorphized. A vacancy associated impurity defect is formed in implantations of ¹¹⁹Sb and - with even larger intensity - of ^{119m}Te. Additionally, in ^{119m}Te implantations a line is observed which is assigned to an oxygen containing defect.

This work has been supported by the Danish Natural Science Research Council.

References

- [1] Weyer, G., Nylandsted Larsen, A., Deutch, B.I., Antoncik, E., and Nielsen, H.L., Inst.Phys. Conf.Ser.<u>31</u> (1977) 491
- [2] Weyer, G., Mössb.Eff.Method.(eds.Gruvermann, I.J. and Seidel, C.W.) <u>10</u> (1976) 301
- [3] Petersen, J.W., thesis, Aarhus 1979
- [4] Weyer, G., Nylandsted Larsen, A., Holm, N.E., and Nielsen, H.L., to be published
- [5] Vogl, W. and Vogl, G., J.Physique Colloq.<u>35</u> (1974) C 6 - 321 and Vogl, W., thesis, München 1974