ESRF	**Experiment title:** Temperature dependent phonon density of states of ^{119}Sn	**Experiment number:** HS - 864
Beamline: ID18	**Date of experiment:** from: 8/7/99 to: 10/7/99	**Date of report:** 10/9/99
Shifts: 8	**Local contact(s):** A. Barla	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):
A. Barla*, R. Rüffer*, A. I. Chumakov
ESRF, BP 220, 38043 Grenoble Cedex, France

Report:

The main aim of experiment HS864 was, as a continuation of experiment HS676, to study the lattice dynamics of Sn in its two phases α (cubic and semiconducting) and β (tetragonal and metallic). Due to the extremely limited beamtime allocated in 16-bunch mode (it is not possible to adjust the high resolution monochromator in any other mode), only test measurements on thin films of tin could be performed.

It is well known that thin films of α-Sn can be grown epitaxially on crystalline substrates having similar lattice constant (CdTe, InSb, Si). These films are stable at temperatures up to $\sim 100\,\mathrm{C}$, while bulk α-Sn transforms to β-Sn at $\mathrm{T} = 13\,\mathrm{C}$. It is so far unknown which phase of tin will occur in thin films produced by sputtering. For our experiment, thin films of tin have been sputtered on Si substrates by Ralf Röhlsberger (University of Rostock), with thicknesses of 150 nm and 300 nm. The density of the films derived from the critical angle of total reflection suggests that α-Sn is formed during the sputtering process.

The NIS measurements have been performed in 16-bunch mode. With the use of a Be compound refractive lens to reduce the divergence of the synchrotron beam, we obtained a flux of $1.8{\cdot}10^7$ photons/s (at 90 mA current in the storage ring) in an energy bandwidth of $\sim 0.65\,\mathrm{meV}$. The maximum countrate was $\sim 0.4\,\mathrm{Hz}$. The sample (thin film with 300 nm thickness) was inserted in a closed cycle cryostat mounted on a diffractometer, and the measurements were carried out at $\mathrm{T} = 300\,\mathrm{K}$ and $\mathrm{T} = 30\,\mathrm{K}$.

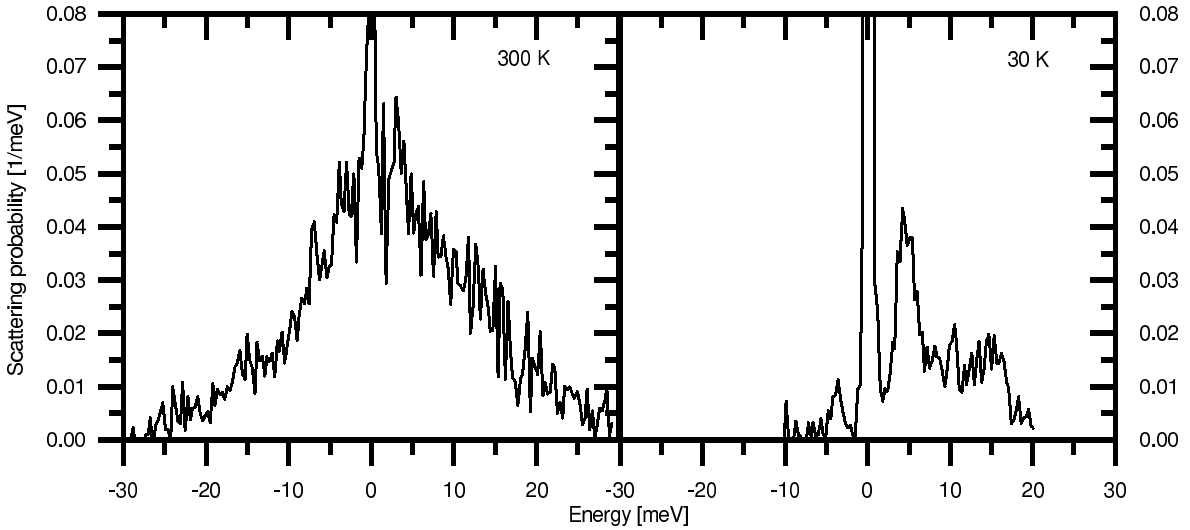

Fig. 1: NIS by a thin film of Sn

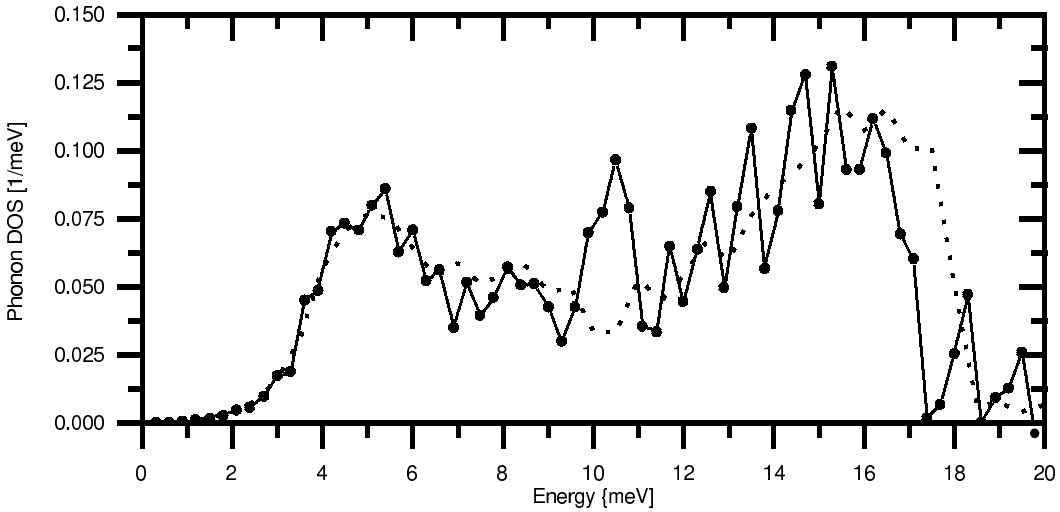

Fig. 2: Comparison between DOS of bulk (dotted line) and thin film (continuous line + dots)

Fig. 1 shows the probability density of NIS by the sample at the two temperatures. Due to a lack of time, the low temperature spectrum could be measured only on a reduced energy interval. It is evident that the room temperature spectrum is dominated by multiphonon processes (in a very similar way to the bulk β-Sn), while the low temperature data show almost only single phonon events. From this last spectrum it is possible to extract the phonon density of states (DOS), which is compared in Fig. 2 with the DOS of bulk β-Sn measured at $T = 100\,K$ during experiment HS676. The low energy parts of the two DOS (up to $\sim 9\,meV$) are very similar to each other, both exhibiting a Debye behaviour only at very low energies (below 3.5 meV) and a broad peak centred at $\sim 5\,meV$, that can be assigned to acoustic phonons. At higher energies there seem to be two main differences between the DOS: the cut-off energy for the thin film seems to be lower by $\sim 1\,meV$ than that of the bulk. Moreover a sharp peak centred at $\sim 10\,meV$ appears only for the thin film, whereas the bulk shows a relative minimum at this energy.

Despite the poor statistics of the thin film data, it seems possible to rule out the presence of α-Sn in the film. For a better analysis of the differences between bulk and thin film the measurements will have to be repeated in a more extended energy interval and at different temperatures.