EXPERIMENT SS-6

Internal Friction in Tantalum Containing Oxygen

In this experiment, kinetic processes occurring on an atomic scale will be studied by mechanical means. Measurements of the temperature dependent internal friction and shear modulus will be used to observe the rearrangement of oxygen atoms dissolved in small concentration in crystalline tantalum, when the latter is periodically stressed. This is an example of the so-called Snoek Effect.

Specifically, this experiment involves three tasks:

1) Determine the activation energy for the rearrangement of the oxygen atoms
2) Determine the diffusion constant (units: cm^2/sec) of oxygen in tantalum, as a function of temperature, and from this estimate the temperature at which 10% of the oxygen would diffuse out of the tantalum wire used in this experiment in, say, 1000 hr (many students have worked on this wire!)
3) Prepare a critical review of earlier investigations of the first task. Make an estimate of the oxygen concentration in your setup. Identify open questions or contradictory statements. To simplify this task reprints of relevant investigations are appended.

The experiment involves measuring from 50°C to 300°C the resonance frequencies and the amplitude decay of a torsional oscillator in which the torsional member is a tantalum wire (diameter 0.76mm, length 25cm, see the appended description of the apparatus (1)). Use six different positions of the brass counter-weights to achieve resonance frequencies between ~ 0.4 and 1.0 H_z. In order to prevent further oxidation of the wire flush argon gas through the furnace housing the Ta wire. A very small rate (about 1cfh) is adequate (is this argon flow at all necessary? See Task 2 above). The experiment is straight-forward, but as every experiment involving temperature, thermal equilibration is crucial and can be tedious. It is suggested that the experiment is done in two steps: On the first day, go through the experiment quickly, for one frequency . Demonstrate at least once that the pendulum amplitude does indeed decay exponentially with time! Evaluate the data so that you learn what to watch out for. Then go back, with one full day set aside for this purpose, and do the entire experiment in one go. In your analysis, consider both the variation of the internal friction and of the shear modules.