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Superconductivity of Hf-Ta and Ta-W Alloys under Pressure

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Measurements on ten binary alloys of the body-centered cubic part of the $5d$-alloy series Hf-Ta and Ta-W yield a linear relationship between the derivatives of the quantity g both with respect to pressure and to valence electron concentration, where g is defined by $T_c \propto \theta \exp(-1/g)$. This result agrees with observations on alloys of the $4d$-series, Zr-Nb and Nb-Mo. It is concluded that for these alloys composed from the central part of the $4d$ and $5d$ transition series, the interaction responsible for superconductivity is less subject to complications than for other transition metals and is probably governed by the electronic density of states. Data on the variation of the transition temperature with concentration in Hf-Ta alloys are included.

Introduction

Improvements in establishing expressions for the superconducting transition temperature T_c, including strong coupling effects[1], and attempts to evaluate the mean electron-phonon interaction parameter from first principles[2,3], have raised doubts about the originally assumed dominating influence of the d-band density of states on T_c in transition metals. Modifications primarily concern the parameter g, defined by the general expression for the transition temperature, $T_c \propto \langle\omega\rangle \exp(-1/g)$. It has become apparent that the simple BCS expression $g_{BCS} = NV_{BCS}$ is to be replaced by $g = f(\lambda, \mu^*) \approx \lambda$, where the electron-phonon coupling constant λ is determined by $\lambda = N\langle J^2\rangle/(M\langle\omega^2\rangle)$ (N = electronic density of states at the Fermi surface, $\langle J^2\rangle$ = average squared coupling matrix element, M = ionic mass, $\langle\omega^2\rangle$ = mean squared phonon frequency)[1].

Empirically it was found for a number of *elemental* metals[1] that $N\langle J^2\rangle$ is almost constant, i.e. λ does not inherently depend on the electronic density of states N. The apparent proportionality between N and λ which is often observed in binary transition metall *alloys* (e.g., Fig. 9 of Ref.[1]) is then to be ascribed to a correlation of N with the phonon spectrum, represented by $M\langle\omega^2\rangle$, which becomes the governing

1 McMillan, W. L.: Phys. Rev. **167**, 331 (1968).
2 Hopfield, J. J.: Phys. Rev. **186**, 443 (1969).
3 Barišic, S., Labbé, J., Friedel, J.: Phys. Rev. Letters **25**, 919 (1970).