THE RELATIONSHIP BETWEEN THE MARTENSITIC PHASE TRANSITION AND
THE SUPERCONDUCTING PROPERTIES OF A15 COMPOUNDS*

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INTRODUCTION
Since the discovery by Batterman and Barrett\textsuperscript{1} in 1964 of the 21 K structural transition in $V_3Si$, soon followed by the discovery of a similar transition in $Nb_3Sn$,\textsuperscript{2} there has been intensive investigation, both theoretical and experimental, of its nature, particularly of its relationship to electronic structure and its coupling to lattice distortions and phonons. [This work is summarized in two excellent reviews by Weger and Goldberg\textsuperscript{3} and by Allen.\textsuperscript{4}] The transition consists of a tetragonal distortion of the originally cubic unit cell (a shear strain distortion) accompanied by a dimerization of the atoms along the transition metal chains (an optic mode distortion); it is usually called the "martensitic" transition, probably because it is diffusionless, although it is more typical of soft-mode transitions\textsuperscript{4} than it is like "classical" martensitic phase transitions.\textsuperscript{5} Since both the structural transition and superconductivity in these compounds are thought to be a consequence of strong electron-lattice coupling, it was thought that an understanding of the relatively simpler structural transition might provide insight into the origin of the relatively high-temperature superconducting transition in intermetallic compounds with the A15 structure. Unfortunately a definitive understanding of either the structural or the superconducting transition in these materials still remains elusive.

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Because the structural and superconducting transitions probably are both manifestations of the same physical phenomenon, they are closely coupled: the spontaneous lattice deformation which accompanies the martensitic transition causes a depression in the temperature of the superconducting transition, whereas if the superconducting transition occurs before the martensitic transition takes place, the latter will be suppressed. Furthermore, applied tetragonal strain, with the same symmetry as that accompanying the martensitic transition, strongly affects (usually adversely) the superconducting critical temperature $T_C$ and magnetic field $H_{c2}$ of Al5 compounds. Thus, it has been suggested recently that inhibiting the martensitic phase transition by the introduction of added elements or deviations from stoichiometry is a possible means of improving the $H_{c2}$ of Nb$_3$Sn for use in technologically useful superconductors, since it has been observed that nontransforming cubic Nb$_3$Sn has a higher value of $H_{c2}$ than that of martensitically transformed tetragonal Nb$_3$Sn.

This paper contains a very brief discussion of the current theoretical ideas on the relation between the martensitic and superconducting transitions in Al5 compounds and a brief review of the experimental evidence on the effect of pressure, alloying additions, and radiation-induced disorder on the coupled transitions as well as the related tetragonal-strain dependence of the superconducting properties.

**THEORY**

Although there exist several phenomenological models which very successfully describe some properties (such as the temperature dependence of elastic constants and of magnetic susceptibility) which are related to the martensitic transition, there is no generally accepted microscopic theory of the transition. [See references 1 and 4 for a critical discussion of the various models.] All of the well-developed models focus on the role of fine structure (on a scale of ~300 K) in the electronic density of states in Al5 compounds and its coupling to the tetragonal distortions of the unit cell and/or to optical phonons which dimerize pairs of atoms along transition metal chains. There are basically two types of theoretical models: models such as that of Labbé and Friedell in which the tetragonal lattice distortion lifts the degeneracy of certain electron bands by shifting the band edges, followed by charge flow to the bands with lowered energy (a band Jahn-Teller effect) and models such as that of Gor’kov in which an optic mode distortion (accompanied by a tetragonal distortion) gives rise to a charge-density wave which creates a gap (the “Peierls gap”) in the electronic spectrum. The two types of models can be roughly distinguished by saying that the former emphasizes interchain charge transfer while the latter emphasizes intrachain charge transfer. Whether