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Superconductivity of high density nonmagnetic cobalt

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Metals possessing strong long-range magnetic order, as in antiferromagnetism or ferromagnetism, do not exhibit superconductivity [1]. This includes ferromagnetic transition metals Fe, Co and Ni. However, some elements, which do not show superconductivity under ambient pressure, become superconducting under higher pressure. Fe has been found to undergo a superconducting transition at pressures between 15 and 30 GPa with a critical temperature (T_c) of about 2 K [2]. Fe is nonmagnetic at this pressure. Superconductivity was not hitherto observed in Co and Ni under any condition. Recently, a high-density nonmagnetic (HDNM) face-centered cubic (*fcc*) phase of Co was discovered in Co thin film [3]. As this phase of Co is nonmagnetic, one can expect superconductivity in this HDNM phase of Co. We have indeed discovered superconductivity in the high-density nonmagnetic Co thin film with a superconducting transition temperature (Tc) of ~9.5 K and a critical field (Hc) of ~ 35 kG [4]. The transition to the superconducting state has been detected by point-contact spectroscopy and drop in resistance in point contact measurements as well as in standard four probe resistivity measurement method. In 4-probe method the transition temperature is ~5.4 K. This difference in transition temp could be due to strain distribution over the film since the strain is playing the key role. First-principles density functional theory calculations for this dense *fcc* phase of Co show that this phase is nonmagnetic and the estimated T_C within the BCS theory is 0.30 K. A volume preserving strain in *fcc* Co is shown to result in anomalous softening of zone boundary phonons which couple strongly with electrons, and stabilize superconductivity at a relatively large temperature (>5 K). The value of T_C can indeed be higher for other strain conditions.

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