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Intertwined Charge Density Wave and Defect-Ordering Phase Transitions in a 2-D System[1]

E. W. Plummer and A. V. Melechko (Department of Physics and Astronomy, The University of Tennessee, Knoxville, TN 37996-1200 and Solid State Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831-6057)

The study of macroscopic properties of phase transitions in low-dimensional systems provides an understanding of the fundamental aspects of systems of interacting particles. Phase transitions are strongly affected by defects, especially in systems with lower dimensionality. In quasi-1D or -2D systems that exhibit a charge density wave (CDW) transition, a small proportion of microscopic disorder can control the global properties because of the collective nature of the phenomena. It has been speculated that the interaction of mobile defects with CDW leads to alignment of defects with the CDW, or the formation of defect density waves[2]. In this dynamic picture, the distribution of defects is neither random nor static; instead, defects align their positions to optimize the energy of the pinned CDW. Here, we will discuss a complex symmetry lowering ($\sqrt{3}x\sqrt{3}$) to (3x3) phase transition in Sn/Ge(111) and similar systems that can be decomposed into two intertwined phase transitions: a second-order CDW transition and a first-order disorder-order transition in the defect distribution. We present two phenomenological models that describe these transitions and their interrelation[3]. These models allow us to understand the formation of the domains and domain walls seen in scanning tunneling microscopy at low temperatures, defect-induced waves above the CDW transition temperature, and ordering of the defects caused by the CDW-mediated defect-defect interactions[4]. The models predict a shift in the CDW transition temperature with impurity density and a dependence of the (3x3) lattice structure on the specific defect alignment.

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