Engineered Heusler Compound Heterostructures and Superlattices

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Abstract

Heusler compounds are a large group of intermetallic compounds with ~1500 members with similar crystal structures having a vast array of tunable properties. This offers the possibility of engineering novel materials and heterostructures possessing properties far beyond what band gap engineering has done for III-V semiconductor technology. These properties depend on the number of valence electrons per formula unit allowing tuning of properties through composition and alloying. Tuning of Heusler compound properties include semiconducting band gap, metallicity, magnetism, half-metallicity, superconductivity, shape memory, and, potentially, piezoelectricity. Combining Heusler compounds with different properties into heterostructures and superlattices allows for fundamental studies as well as engineered applications of magnetoresistance and superconducting proximity effects coupled with shape memory and piezoelectricity. Despite the wealth of tunable properties and potential for tailored dissimilar properties heterostructures, studies of heterostructures and superlattices have not been performed. In this proposed study, molecular beam epitaxy and chemical beam epitaxy will be used to grow and tailor Heusler heterostructures and superlatttices combining magnetic, half metallic, superconducting, shape memory, topological and semiconducting Heusler compounds to develop a fundamental scientific understanding of coupling and engineering of their properties. Control of composition, structure and defects is essential to gain knowledge of intrinsic properties and their tailoring. In-situ and ex-situ atomic level structural, electronic and magnetic characterization techniques including superconducting tunneling spectroscopy will be used to study and provide feedback control of surface, interface and bulk properties. The use of chemical beam epitaxy is to develop a growth process that will enable a self-limiting growth condition to improve stoichiometry control. By growing on III-V semiconductor and Perovskite complex oxides, the Heusler heterostructures will be coupled to materials and heterostructures with additional multifunctional properties. The ultimate goal is to develop the new field of multifunctional Heusler compound heterostructures and superlattices.