FUNCTIONAL THIN FILMS BY DESIGN: EMPLOYING RESONANCE BONDING TO TAILOR THERMOELCTRIC AND PHASE CHANGE MATERIALS

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Phase change and thermoelectric materials utilize remarkable property portfolios, which have made it difficult to design such materials, other than employing trial and error approaches. In this presentation, an alternative is discussed. Phase change materials are characterized by the ability to rapidly switch between the amorphous and crystalline state, which differ significantly in their properties. This material combination makes them very attractive for data storage applications in rewriteable optical data storage, where the pronounced difference of optical properties between the amorphous and crystalline state is used. This unconventional class of materials is also the basis of a storage concept to replace flash memory. This talk will discuss the unique material properties, which characterize phase change materials. In particular, it will be shown that only a rather small group of materials utilizes resonance bonding, a particular flavour of covalent bonding, which can explain many of the characteristic features of phase change materials. This insight is employed to predict systematic property trends and to explore the limits in stoichiometry for such memory applications. It will be demonstrated how this concept can be used to tailor the electrical and thermal conductivity of phase change materials. It even can be utilized to identify thermoelectric materials with large figures of merit. Yet, the discoveries presented here also force us to revisit the concept of resonance bonding and bring back a history of vivid scientific disputes about ‘the nature of the chemical bond’.