Phase Transformations Leading to Heterostructure Formation and Direct Exchange Interactions in Epitaxial Nanostructures

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Bottom-up fabrication of functional nanostructures requires deep understanding of nucleation and growth processes and their effect on the resulting individual and collective physical properties. The former processes are best observed by in-situ scanning tunneling microscopy (STM). For exploring magnetism at the nanoscale, it makes sense to begin with growing nanostructures of ferromagnetic (FM) elements, such as Fe, Ni and Co, on the substrates of choice. However, as for obvious reasons the substrate of choice is silicon, the reaction of FM adatoms with Si leads to formation of superparamagnetic (SPM) arrays of nanometric silicide islands. On the other hand, the affinity of transition metals for Si, lends itself to selective reaction of the metal adatoms at specific surface sites, affecting not only positioning but the nanostructure size and shape, as well. This way we could tackle the problem of SPM limit by inducing collective dipolar interactions between densely packed islands within ordered or disordered arrays. For other applications, such as magnetic memory cells, magnetic stability of each individual island is required (rather than collective). In this talk, I will show how we approached this goal by using binary FM alloys, e.g., $Ni_{20}Fe_{80}$ Permalloy, instead of elemental metals. In particular, phase transformations and layering inside the ternary silicide islands upon anneal, form FM-FM or FM-AFM sandwich structures coupled by direct exchange interactions.