Mechanical Alloying (MA) is a process that involves repeated cold welding, fracturing and rewinding of powder particles in a high-energy ball mill and has been used extensively to synthesize both stable (equilibrium) and metastable phases in a number of alloy systems. This is due to its ability to achieve many effects simultaneously, viz., reduction in grain size, introduction of a variety of crystal defects, disordering of the lattice, and modifying the crystal structures of materials; all these allowing alloying and phase transformations to occur in powders. In this Dissertation, we have synthesized a number of different alloy phases in Fe- and Ni-based alloy systems using MA.

The as-received, blended, and milled powders were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and transmission electron microscopy (TEM) techniques to obtain information about the overall microstructure and chemical compositions. The NiX2 (X = Ge and Si) phases were synthesized in the Ni-Ge and Ni-Si systems. MA of Ni-Ge powder blends was investigated to study phase evolution as a function of milling time. On milling the powders for 5 h, the equilibrium NiGe phase started to form, and its amount in the powder increased with increasing milling time. On milling for about 60 h, the equilibrium intermetallic NiGe and Ge powder particles reacted to form the metastable NiGe2 phase. However, on milling for a longer time (75 h), the metastable phase transformed back to the equilibrium NiGe phase.

Synthesis of the NiSi2 intermetallic phase depended on the Si content. For example, while in the Ni-60 at.% Si powder blend, only the NiSi phase was present homogeneously, the powder blend of the Ni-67 at.% Si composition contained the NiSi phase along with a small amount of unreacted Si. This constitution in the milled powder has been attributed to a partial loss of Si content during MA. But in the Ni-75 at.% Si and Ni-80 at.% compositions, the NiSi phase that had formed earlier (after 2 h of milling) and the remaining free Si powder reacted to form the equilibrium intermetallic NiSi2 phase. Formation of NiSi(Si) solid solutions with a solubility of about 18.2 at.% and 20.6 at.% for the Ni-75 at.% Si and Ni-80 at.% Si powder blends, respectively, was also achieved in the early stages of MA.

In the case of the Fe-18Cr-xNi (x = 8, 12, and 20) system, the current investigation showed that the phase constitution depended significantly on the Ni content in the powder blend. Whereas the ferrite and austenite phase mixture was present at lower Ni contents, a completely homogeneous austenite phase was present in the alloy with 20% Ni.

In the Fe-C system, we were able to synthesize the ferrite, cementite, and mixtures of the two phases. We were able to obtain the Fe-C solid solution phase (ferrite) with a BCC structure and the cementite phase, with an orthorhombic structure in the Fe-0.8 wt. % C composition, while a homogeneous cementite phase had formed at the higher carbon content of Fe-7.0 wt. % C after 30 h of milling time.

Major: Materials Science and Engineering

Educational Career:
Bachelor's of Materials Science and Engineering, BS, 2004, Technological University, Baghdad, Iraq
Master's of Materials Science and Engineering, MS, 2015, University of Central Florida, Orlando, U.S.A.

Committee in Charge:
C. Suryanarayana, Chair, Materials Science and Engineering
Raj Vaidyanathan, Materials Science and Engineering
Ruey-Hung Chen, Mechanical and Aerospace Engineering
Linan An, Materials Science & Engineering
Jihua Gou, Materials Science & Engineering

Approved for distribution by C. Suryanarayana, Committee Chair, on June 13, 2016.
The public is welcome to attend.