Surprising Properties of Matters in Nano-Scale

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I shall first give a brief overview of the exciting development in condensed matter physics with matter in the nano-scale, particularly focuses on the recent works carried out by scientists in Taiwan. Then I'll present our recent works on the understanding of the physics in the new Fe-based superconductors, especially the FeSe and related compounds. We observed that new FeSe phases could be stabilized in nano-dimensional form. For example, we can use a rather simple process to grow highly crystalline -FeSe-type nanowires (NWs). Three kinds of NWs, Fe-Se, Fe-Se-Te and Fe-Te-S, have been prepared and carefully characterized by transmission electron microscope (TEM). Most of the Fe-Se NWs are found to exhibit Se-rich in chemical composition. The ratio of Se/Fe in Fe-Se nanowires is found close to 5/4, but with tetragonal crystal symmetry. Detailed analytical electron microscopy on this crystal and with multi-slice simulation show that the new phase exhibits iron-vacancy ordering of 2 x 2 d110 with 1/2 d100 shift every other (001) plane (the Fe-Se layer). Preliminary electronic band structure calculation of this new phase reveals a considerable modification around the Fermi surface mainly contributed by the Fe-d orbitals. In addition, we also observed several different kinds of iron-vacancy ordering depending on the stoichiometry of the synthesized Fe-Se nano-particles or nanowires. Our results further suggest that the tetragonal symmetry t-Fe_3Se_4 is likely the parent compound of the FeSe superconductors. These results provide us a more clear picture to realize the mechanism of superconductivity in Fe-Se system.