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BRNO UNIVERSITY OF TECHNOLOGY

ADVANCED MATERIALS AND NANOTECHNOLOGY

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High mobility strained Germanium low-dimensional systems

MAY, 22

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Seminar room **S2.02**
CEITEC BUT, Purkynova 123

Carrier mobility is one of the most important parameters of any semiconductor material, determining its suitability for applications in a large variety of electronic devices including field effect transistors (FETs). Bulk or 3D, Germanium (Ge), with its very high intrinsic hole and electron mobilities of 1900 and 3900 cm2V-1s-1 at room temperature, respectively, is the most promising candidate material to replace Si channels in future complementary metal oxide semiconductor (CMOS) devices. When one or more of the dimensions of a solid are reduced sufficiently to nanometer range, its physicochemical characteristics notably depart from those of the bulk solid. With reduction in size, novel electrical, mechanical, chemical, magnetic, and optical properties can be introduced. The resulting structure is then called a low-dimensional structure or system.

Biaxial compressive strain in nm scale thick Ge epilayer narrows its band gap and causes the appearance of a quantum well (QW) in the valence band. Holes confined in the strained Ge QW form a two-dimensional hole gas (2DHG) and have an increased mobility due both to their lower effective mass and reduced scattering factors in this material system. During the recent years a major breakthrough have been achieved in enhancement of carrier mobility in strained epitaxial Ge grown on a standard Si(001) substrate. Extremely high room- and low-temperature 2DHG mobilities of up to 4,500 cm2V-1s-1 and 1,500,000 cm2V-1s-1, respectively, have been demonstrated. These hole mobilities are the highest not only among the group-IV Si and Ge based semiconductors, but also among p-type III–V and II–VI materials.

The latest achievements reveal a huge potential for future applications of this material in a wide variety of electronic devices. Enhanced electron and hole mobilities are not only important for future device applications, but they can also provide new insights in the transport properties of low-dimensional carrier gases and the discovery of new quantum phenomena. The high mobility Si and Ge QW heterostructures created the foundation and served as an excellent demonstration platform, which has already stimulated research, not only on other Group IV semiconductors consisting of elemental Si, Ge, C and Sn, but encouraged integration of other well established III-V materials like GaAs, InGaAs, InSb and others on the same Si substrate. Also, more and more experimental evidence proves that the strained Ge system is an excellent vehicle for basic materials science and quantum physics, with the demonstration of a number of very interesting quantum phenomena including ballistic quantisation, Stark effect, Rashba spin splitting, Weak Antilocalisation, Fractional Quantum Hall effect, Terahertz quantum Hall and others. The 2DHG mobilities in strained Ge are already sufficiently high to fabricate sub-100 nm electronic devices and demonstrate ballistic transport therein at or around room temperature and will, without doubt, be an excellent platform for scientists to discover even more new quantum phenomena and applications in this excellent material.