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Conference Report

11th International Conference on High-Pressure Semiconductor Physics (HPSP-11), Berkeley, USA, 2–5 August 2004

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Conference Reports are meant to offer an authoritative view on a recently held scientific meeting rather than a comprehensive list of the conference presentations. Authors are invited to describe what they feel were the most interesting contributions.

The Proceedings of the 11th International Conference on High-Pressure Semiconductor Physics (HPSP-11) will be published in phys. stat. sol. (b) in November 2004.

The 11th International Conference on High-Pressure Semiconductor Physics was held in Berkeley, California, as a satellite of the much larger 27th International Conference on the Physics of Semiconductors (ICPS-27), which had been held a week earlier in Flagstaff, Arizona. Most of the previous HPSP conferences – Guildford, UK (2002), Sapporo (2000), Thessaloniki (1998), Schwäbisch Gmünd, Germany (1996), Vancouver (1994), Kyoto (1992), Porto Carras, Greece (1990), Tomaszow, Poland (1988), Montpellier (1987) and Celestynow, Poland (1985) – were also held as satellites of the corresponding ICPS. The proceedings of these conferences have been published in *physica status solidi (b)* since 1996 and constitute an excellent record, for students and researchers, of the center-of-gravity and the highlights of the field. The HPSP-11 was attended by 63 registered participants.

36 invited (30 min) plus contributed (15 min) papers were delivered orally and 41 were presented as posters. The venue was the Conference Center at the Clark Kerr Campus of UC Berkeley, within walking distance of the main campus, in an area offering the widest range of accommodations and gastronomical possibilities. The Joseph W. Krutch Theater, where the lectures were held, was excellent and could have accommodated twice as many participants. Unfortunately, the number of foreign participants was less than that in previous conferences due, no doubt, to the visa restrictions currently in force in the USA. The same problem had afflicted the ICPS "parent conference" in Flagstaff.

A conference highlight was the presence of Prof. William Paul, the father of the field. In his opening lecture he reviewed the early days in which he demonstrated the usefulness of high pressure measurements (up to ~3 GPa those days) for unraveling the details of the band structure of tetrahedral semiconductors. In 1952 he arrived at Harvard from Aberdeen, as a young post-doc, in order to solve a problem related to the pressure and temperature dependence of the gap of PbS, using the legendary pressure equipment of Prof. Bridgman (Nobel Laureate, 1946). Bridgman was on the verge of retirement and, in due course, Bill Paul was given the opportunity of reorganizing and redirecting his laboratory at a time when semiconductors were at the center of solid state physics and technology. He stayed at Harvard until his recent retirement (having been one of his graduate students there, I do not blame him!).

Ever since the days of Bridgman, high-pressure physics has been strongly tied to technological developments, mainly concerning high-pressure generators, but also the peripheral experimental

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Group of participants attending the HPSP-11 conference standing in front of the Joseph W. Krutch Theater, Berkeley, August 2004.

techniques (e.g., in recent years, synchrotron radiation). Among the landmarks in the high pressure equipment one may mention the invention of the belt apparatus by Bridgman, the introduction of capillary tubing by him and W. Paul, optical windows and electrical feedthroughs, the diamond anvil cell, DAC (and the concomitant ruby calibration procedure), and the use of helium as pressure transmitting fluid. Among the developments in ancillary equipment I mentioned laser Raman spectroscopy and synchrotron radiation.

The DAC being well established as the most versatile pressure generator, the number of communications dealing with pressure techniques at the HPSP-11 was small. I was particularly fascinated by the work using pressure indentation in connection with transmission electron microscopy and Raman spectroscopy. In the case of silicon, high-pressure phases were produced by indentation. Some of them remained stable or metastable after removing the indenter.

Ultrahigh pressures have been obtained already for many years by using shock waves. Experiments were presented at this conference in which pressures over 100 GPa were reached and applied to low Z elemental fluids (H, N, O, Rb …), in order to investigate the insulator–metal transition and its universal character.

Concerning phonons under pressure and related phase transitions, laser Raman spectroscopy (LRS) seems to be well established as the choice technique. The real-time variation using coherent phonons, superior to LRS for low-frequency excitations, was also represented at the conference.

These techniques have the drawback of only accessing phonons near the center of the Brillouin zone (BZ). The Paris–Edinburgh cell, developed by Michel Besson (shortly before his untimely death) and co-workers for neutron scattering under high pressure, enables access throughout the whole BZ. Except for a review of its capabilities at one of the opeining talks, however, no recent work was presented at the HPSP-11. The same applies to the powerful technique of Raman scattering using strongly monochromatized X-rays (synchrotron radiation). The alternative technique of LRS using crystals with folded Brillouin zones (e.g., chalcopyrites or superlattices), however, was well represented. A relatively new development for phonon studies is the availability of crystals with different isotopic compositions. Variations of isotopic masses can complement high-pressure measurements in the investigation of anharmonic effects on phonon frequencies and linewidths.

Theoretical studies are very important for the interpretation and understanding of high-pressure effects. In recent years, *ab initio* techniques based on band structure calculations have played a leading role. They allow not only the prediction of phase transitions induced by pressure, but also the investigation of the pressure dependence of electronic excitations (energy gaps vs. pressure) and vibrational states (phonons, localized vibrations). Computer codes to perform such calculations are now of the public domain, or can be acquired at a nominal cost, so that experimentalists well versed in computation can perform these calculations by themselves. One must, however, add the *caveat* that they should make an effort to understand the contents and limitations of such programs. Such caveat was not always heeded in the calculations presented at the HPSP-11 conference.

At the core of *ab initio* programs is always the so-called *local density approximation* (or one of its variants). It must be appropriately modified in order to treat atoms with occupied f-electron states such as the Sm and Eu chalcogenides. Calculations using the *self-interaction corrected local spin density approximation* were presented. They account well for the electronic phase transitions observed in these materials.

It is interesting to note that, in spite of the progress just mentioned, and the public availability of *ab initio* codes, *sticks-and-balls* models still play a role in the interpretation of current high-pressure work on phase transitions. At the opposite end of the theoretical sophistication spectrum one must mention the prediction of crystal structures based on *ab initio* molecular dynamic methods which even go beyond the Parrinello–Rahman techniques.

Among the early achievements in the field of semiconductors under high pressure we must mention Paul's rule: *similar gaps have similar behavior under high pressure*. This rule played an important role in the early identification of gap symmetries. A report at this conference discussed *ab initio* calculations which confirm the semi-quantitative correctness of this rule while unraveling the systematics of quantitative deviations. Another report presented the theoretical background of the anti-crossing of band states with localized levels observed a few years ago for the GaAs:N system.

On the experimental side, carbon nanotubes, their vibrations and electronic gaps, were strongly represented at the HPSP-11. A large number of papers dealt with investigations of lasers under high pressure. They arrived at a better understanding of the laser mechanisms as well as to possibilities of improving commercial units. Unfortunately, no work was presented at the HPSP-11 devoted to the effects of uniaxial stress on lasers and other devices. Such effects are nowadays the basis of a multimillion dollar industry and the organizers of the next conference, to be held in Spain near Barcelona as a satellite to the ICPS-28 (Vienna, 2006) should make an effort to attract to the meeting some of the leading technologists in the field, as well as related work using uniaxial stress.

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