12th International Conference on the Physics of Semiconductors

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The history of the series of IUPAP-sponsored biannual conferences covering the vast field of semiconductor physics reflects the rapid growth of this field dating back to the time between the invention of the transistor in 1948 and the early sixties. In later years it was often discussed whether the field would still be active enough to make the effort of a large international conference to be held every other year really worthwhile. One reason for this soul-searching was the fact that a number of sub-fields started an independent conference life on their own or through marriage with other areas in solid state physics. A long list containing device research, photoconductivity, luminescence, light scattering and various other fields of spectroscopy, lattice dynamics, surface physics, magnetic semiconductors and amorphous solids could certainly not even claim completeness. In such a situation it is the main task of the organizers to avoid polishing the empty shell and to rather fill it with new life by encouraging and emphasizing new tendencies and directions. Judging from the ratio of submitted to accepted contributed papers (>3), the liveliness of discussions and controversies and from the general consensus, the Stuttgart meeting gave ample proof that semiconductor physics is very much alive.

Effects in semiconductors due to high intensity excitation were among the subjects heavily discussed. In these experiments mostly the radiation of sufficiently powerful lasers is used to generate a large number of electron-hole pairs in the crystal. At low temperatures a large fraction of these electron-hole pairs bind in a hydrogen-like state called the exciton. The review papers of M.T. Rice and M. Voos have shown that generally experiments and their interpretation show that at sufficiently high excitation in very pure Ge and Si an electron-hole pair plasma state is more stable than an equal number of free excitons. This state consists of electron-hole plasma drops (EHD) of about 7 μ diameter embedded in an "atmosphere" of excitons. This state is in fact quite similar to a liquid-gas equilibrbium. However, the actual phase diagram may show characteristic differences with respect to an ordinary liquid-gas system, as has been put forward but not yet confirmed experimentally. The reported observation of giant EHD's (of up to 400 μ diameter) in Ge by a group of Berkeley may be related to this question but still remains a subject of controversy.

The problem of surface energy and a possible surface charge of EHD's has attracted theorists in the past. Ya. Pokrovski, one of the first experimentalists in the field, gave an account of experiments in Ge which revealed the existence of a net negative charge on EHD's in general agreement with earlier calculations of M.T. Rice. Other experimental evidence for the surface properties just mentioned came from an analysis of the EHD radius as a function of temperature measured by light scattering at the Lebedev Institute in Moscow. The work of this group and experiments performed at Stuttgart and the University of Southern California seem to indicate further that in slightly less pure Ge and Si impurities may act as nucleation centers for EHD's. However, the nucleation process is very difficult to understand and more work in this direction is needed.

In some other materials there may exist a real quantum effect when excitons are present at high densities. It was observed some time ago that excitons may form the hydrogen-molecule equivalent called a biexciton (excitonic molecule) as the most stable state. The experimental evidence for Bose-Einstein condensation of biexcitons in CdSe and Bose-Einstein condensation of excitons in AgBr has been discussed in the October issue of Europhysics News, and it will therefore not be mentioned here any further.

Certainly of growing interest and importance is the work on optical spin polarization of charge carriers and excitons in semiconductors. Relatively large degrees of polarization have been achieved e.g., for electrons and recently also for excitons (up to 80 % in CdS). As G. Lampel discussed in his talk, these polarizations require a long spin-relaxation time as compared to the lifetime. Both time constants can be obtained directly from these experiments yielding new information about spin dependent recombination processes and the like. In the case of charge carriers the orientation effect is achieved by generating nonequilibrium concentrations in different Zeeman levels by optical pumping. In the case of excitons resonance-like excitation of exciton luminescence with circular polarized light leads to polarization of excitons. Furthermore, a dynamic nuclear orientation has been generated by polarized electrons which indirectly may open the possibility of optical detection of NMR.

A long standing problem is that of impurity states, particularly deep states, in semiconductors. The effective-mass theory (EMT) of Kohn and Luttinger (1955) using a point charge model to describe the impurity allowed one to calculate the excited levels and, with moderate success, also the ground state of shallow (< about 0.1 eV) impurity states. For deep levels (> about 0.1 eV) the EMT has been considered inapplicable. Considerable progress has been made (Baldereschi, Pantelides) by a) taking into account a realistic unperturbed electronic band structure of the host crystal and screening effects near the impurity atom as well as b) introducing local model (or pseudo-) potentials to describe the impurity. This approach has a much broader range of validity than the original EMT. In fact, it gave quantitative agreement with many experimental values of shallow or deep impurity levels, even as deep as about 1 eV.

A great deal of interest centered around dimensionality effects. Review papers on the Peierls transition in "onedimensional" solids (Zeller), on electrons in "twodimensional" layer structures (Yoffe), on electron spectroscopy and photoemission spectroscopy of semiconductor surfaces (Ibach, Grobman) and on the inversion layer in metal-oxide-semiconductor devices (Uemura) set the scene for a large number of contributed papers dealing with various physical properties of low-dimensionality systems. One of the most discussed subjects was the formation of superlattices via Peierls distortion or by a charge density wave. Such superstructures occur in chain- and layerstructures as well as on clean semiconductor surfaces. Other phenomena studied include interlayer interaction, which can be modified by intercalation by a wide variety of molecules, experimental determination and theoretical calculation of surface density of states and, last not least, galvanomagnetic properties and cyclotron resonance in inversion layers.

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