Optoelectronics at the Institute of Electron Technology

Bohdan Mroziewicz

Institute of Electron Technology
al. Lotników 32/46, 02-668 Warszawa

First semiconductor laser developed in 1965 by a small research team of young enthusiasts working at the Electronics Department of the Institute of Fundamental Technical Problems (Polish Academy of Sciences), however simple, marked the beginning of semiconductor optoelectronics in our country. What is more, this tiny device became, as anywhere else, a driving force for progress in research on many other III-V semiconductor devices. Essential to this progress was establishment of the Institute of Electron Technology in 1966 into which the Electronics Department of IFTP was merged. Foundation of the new Institute stimulated a substantial increase of the number of groups working on optoelectronics and created new technical opportunities.

In the 1970's research effort in optoelectronics was focused on visible light emitting diodes and numerical displays made of GaAsP or GaP and on high efficiency infrared GaAs:Zn andGaAs:Si emitters. Simultaneously, silicon and germanium based photodetectors as well as wide variety of opto-couplers were investigated [1]. Altogether over sixty various types of optoelectronic devices have been developed and implemented to mass production in Warsaw TEWA factory, in its division built from the scratch under supervision of the specialists from the Institute. At that time the Optoelectronics Division of the Institute employed over 100 people including a significant number of specialists trained both in Poland and abroad. The aims of their work were well defined. Optoelectronics had been long ago perceived by the authorities as a very important domain and domestic ability to manufacture optoelectronics devices was considered vital to the country in the presence of import restrictions imposed by COCOM regulations.

The arguments of self efficiency became even more important when optical fibre communication systems became reality in more advanced countries. It is to be appreciated that there were in Poland at that time scientists with wisdom and far reaching imagination like professors Adam Smoliński and Zenon Szpigler of Warsaw University of Technology who envisioned significance of this new technology and encouraged scientific community to undertake research in this field.

Thus, from the beginning of the 1980's, through the whole decade, the research potential of the Optoelectronics Division of ITE was aimed at the development of semiconductor emitters and detectors for fibre optic communication systems. As a result a large number of various emitters designed for operation in the 0.85 μm and 1.3 μm optical fibre transmission windows have been developed [2]. At the same time the work on high power semiconductor lasers has been revived. The latter have been the DH (double heterojunction) or and SCH (Separately Confined Heterostructure) type broad contact in which current was confined to the wide stripe active region by a high mesa and the Schottky-barrier isolation outside the mesa (Fig. 1). Length of the emission spot in these lasers was as large as 300 μm while the resonator was 250 μm or 500 μm long. Depending on the particular type of the laser its output power could reach 15 W in 200 ns pulses.

Semiconductor lasers operate at extremely high current and optical power densities and therefore can be sufficiently reliable only if made by well controlled technological operations. To meet this requirement the following processes with regard to AIII-BV compounds had to be learned and become standard routine at the IET: thin layer epitaxy (LPE), diffusion, metallization and contacts formation, insulation layers deposition, photolithography, dry and wet etching, reflection and antireflection layers coating, and chip and wire bonding. These technologies have been developed for GaAs, InP, AlGaAs, InGaAsP and InGaAs compounds, but may be extended to other AIII-BV semiconductors if required. They have been supported by measurement techniques like SIMS, electro-chemical profiling, photoluminescence scanning, SEM and variety of other electro-optical techniques employed to characterise materials and heterostructures. Appropriate methods of evaluation of laser chips and assembled devices at any stage of their fabrication have also been developed.

Recent years have brought the rules of free market economy and the Institute is presently operating in a totally new environment. Its activity on optoelectronics will have to be adjusted to this new situation using all the accumulated

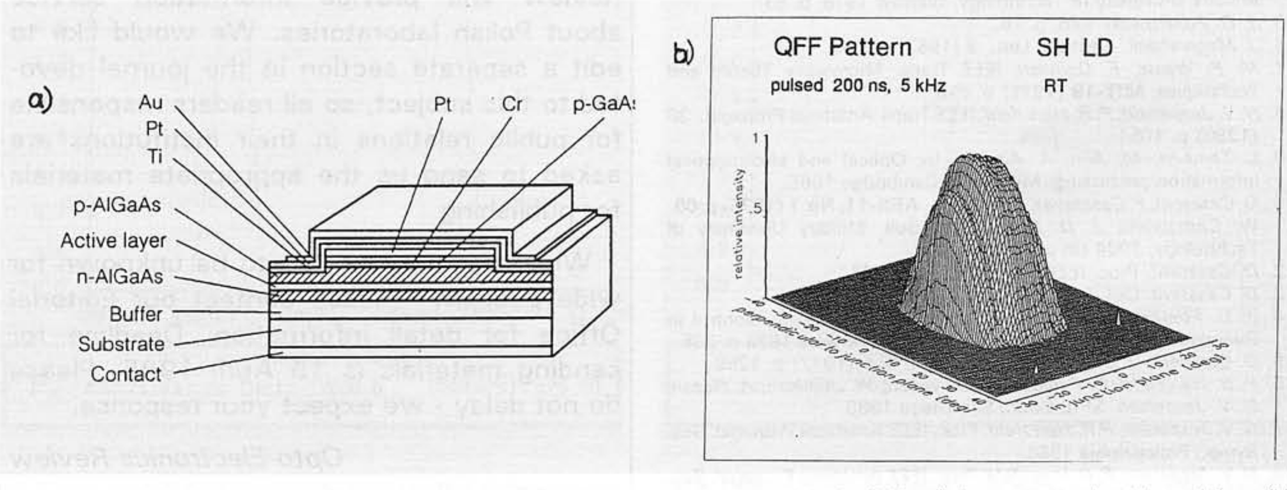

Fig. 1. Schematic diagram of high power board-contact DH AlGaAs/GaAs laser (a) and the far field radiation pattern emitted by such laser (b)

scientific and technical potential. The work on lasers should receive a great support from research carried out at the Institute on MBE – molecular beam epitaxy (see Fig. 2). It is because this technology provides means for growing heterostructures with quantum wells without which no modern lasers can be fabricated. So far the group working on MBE has achieved a reproducible growth of AlGaAs/GaAs quantum wells with different thicknesses as low as few atomic layers. Photoluminescence studies prove very high perfection of grown layers (Fig. 3) confirmed by record carried mobility ($\mu = 10^5\,200\ \mathrm{cm^2/Vs}$ at 77 K) obtained for undoped layers ($n = 1.5 \cdot 10^{14}\ \mathrm{cm^{-3}}$).

In summary, the past and the present in the 30 years old history of optoelectronics have been marked with various achievements which contribute to scientific and technical potential of the Institute in this field. It is to be seen how this potential will be exploited in future developments.

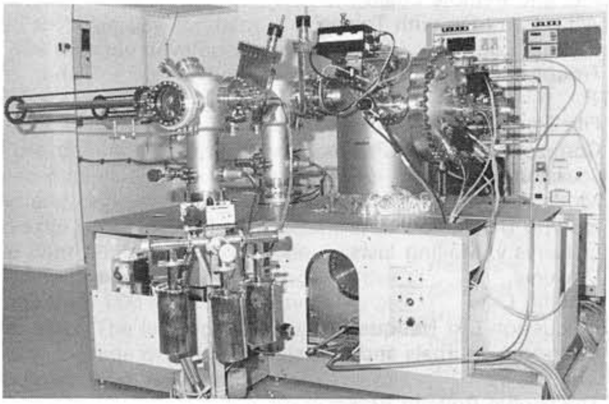

Fig. 2. A view of the MBE reactor installed at the Institute of Electron Technology. The reactor is the RIBER 32P machine containing 7 (or 8) effusion cells and accomodating up to 8 of 2" substrates

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About the author

Prof. Bohdan Mroziewicz is a senior scientist at the Institute of Electron Technology. Engaged since 1955 in research on semiconductor technology was among the first in Poland who started work on semiconductor light emitting devices. Then for over 20 years served as head of the Optoelectronics Division at the Institute.

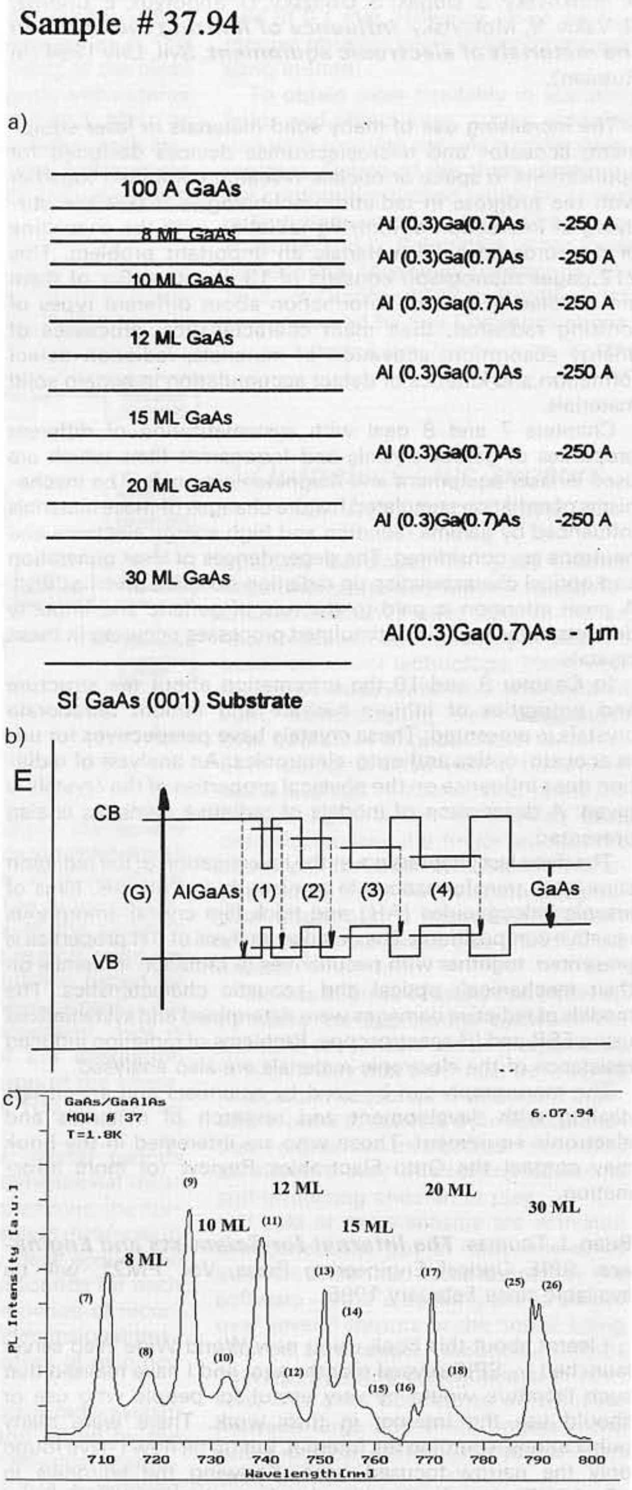

Fig. 3. Schematic of a MQW structure grown by MBE (a), its band diagram (b) and photoluminescence response (c). Photoluminescence results show high quality of the interfaces. Splitting of the low temperature PL lines into 3 components proves that interfaces on a mesoscopic scale are atomically flat with monolayer step (island) dimensions greater than exciton diameter ($L >> D_{ex} \approx 200$ Å). For the narrowest wells (8ML and 10ML) submonolayer splitting of PL lines is visible, resulting from microroughness on a scale small comparing to step (island) size and exciton diameter ($d_r << L$, $d_r << D_{ex}$). The linewidths of PL lines from narrow quantum wells are comparable with state-of-the-art values reported by other laboratories