To search page

1979
Invention of the HEMT (Fujitsu)

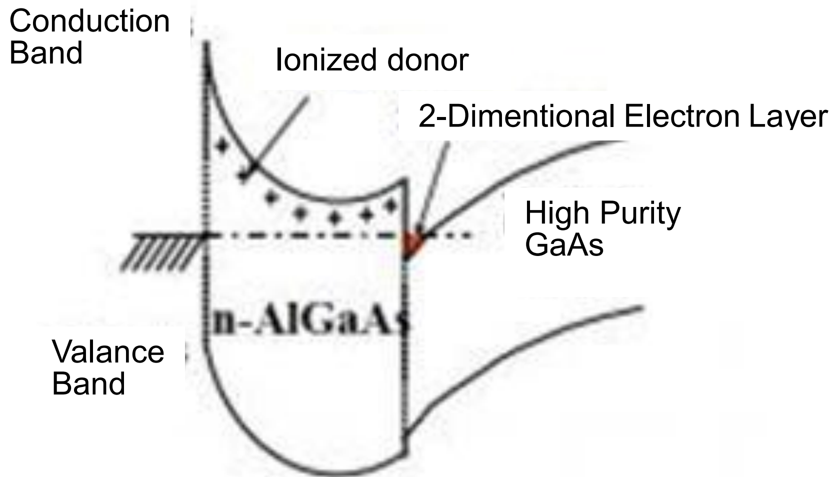
~ Discrete Semiconductor/Others ~

In 1978, R. Dingle et al. of Bell Laboratories succeeded in the accumulation of electrons in the GaAs layer, by modulation doped superlattice structure (alternate lamination of Si-doped n-type AlGaAs ultra-thin layer and high purity GaAs ultra-thin layer). Mimura of Fujitsu got an idea of making a field effect transistor by using only one junction interface of this superlattice and named it HEMT (High Electron Mobility Transistor). In cooperation with Hiyamizu of Fujitsu Laboratories who was studying molecular beam epitaxy (MBE) crystal growth technology which was necessary for realizing heterojunction with steep composition change enabled by its nature of little auto-doping, they succeeded in the operation of the HEMT. They filed the patent application and the press release in December 1979, and presented a paper at DRC in June 1980. At the paper presentation, Thomson (France) also reported a successful operation of the similar device, with only a tiny time difference.

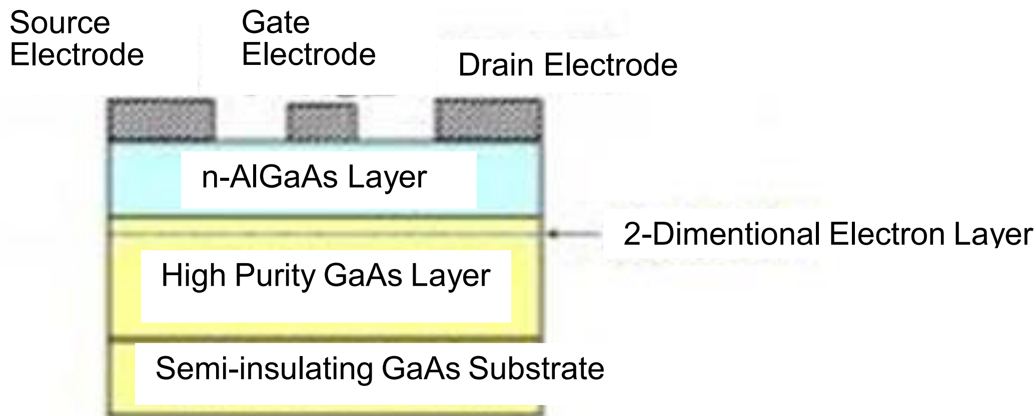
Since HEMT achieved high electron mobility of about 50,000 cm 2/Vs at 77K, it attracted attention as a high frequency and high speed device.
It was initially adapted as one of the key elements in MITI’s large-scale “High-speed Scientific Computer System” project (Super Computer Project) and aimed to develop elements for super computers in 10 years plan. 1K SRAM was developed in 1983, and 16KSRAM in 1986. An 1100 gate logic LSI were successively developed in 1988. However, in order to obtain sufficient performance, liquid nitrogen temperature operation was necessary, and performance of the complementary HEMT was not sufficient, and so, it developed as an element for microwave and millimeter wave communication rather than a logic device.

In the HEMT crystal, a high-purity GaAs layer and an AlGaAs layer doped with high concentration Si are grown on a semi-insulating GaAs substrate. It is important that a flat heterojunction interface is secured and Al and dopant Si do not diffuse into the GaAs layer during growth of the AlGaAs layer. Therefore, MBE and MOVPE (Metal Organic Vapor Phase Epitaxy) are used for which the crystal growth temperatures are low and precise control of crystal growth is possible.

With the advent of HEMT, the importance of heterojunction related technology, MBE technology, MOVPE technology, etc. was recognized, and the contribution for activating these research and development is also important.



HEMT band structure



Structure outline of HEMT

Reference:

(1) T. Mimura et. Al. "A new field-effect transistor with selectively doped GaAS/n-AlGaAs heterojunction" Japanese J. Appl. Phys. Vol. 19, L225, (1980)

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