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Mimura T, Hiyamizu S, Fujii T & Nanbu K. A new field-effect transistor with selectively doped GaAs/n-$Al_xGa_{1-x}As$ heterojunctions. *Jpn. J. Appl. Phys.* 19:L225-7, 1980.
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Experiments on field-effect control of the high mobility two-dimensional electron gas at a GaAs/n-$Al_xGa_{1-x}As$ heterointerface were reported. A new field-effect transistor, called a high electron mobility transistor, was demonstrated. [The *SCI*® indicates that this paper has been cited in more than 280 publications.]

Modulating Two-Dimensional Electron Gas

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In 1977, my primary intention when I started a research program on GaAs MOSFETs at Fujitsu Laboratories Ltd., Kawasaki, Japan, was to confirm electron accumulation at the interface between pure GaAs and oxide. Despite our effort, the high density of interface states in the MOS system prevented us from observing this electron accumulation.

In the spring of 1979, the work of R. Dingle and others was brought to my attention. They reported a superlattice structure consisting of alternating thin layers of undoped GaAs and n-type AlGaAs, emphasizing the mobility enhancement for electrons confined in the potential wells of undoped pure GaAs layers.[1]

What impressed me about their work was not so much their objective to observe mobility enhancement but the fact that electrons accumulated in pure GaAs layers. This accumulation was made possible by the low density of interface states in the GaAs-AlGaAs heterointerface. I had not reached the stage, however, of considering practical uses for the superlattices. This was probably due to my complete concentration on GaAs MOS research and preoccupation with preparing a GaAs MOSFET manuscript[2] for the 37th Device Research Conference, June 1979.

At the conference, however, it occurred to me that a practical device might be made by modulating the two-dimensional electron gas (2DEG) accumulated at the pure GaAs side of the heterointerface. Within weeks, I had invented a type of field effect transistor. The patent application was filed on 28 December 1979 and a patent issued on 8 September 1987.[3]

The important concept leading to the invention is the interaction between the surface and interface depletion regions depleting the entire n-type AlGaAs layer. This enables the Schottky barrier gate on the AlGaAs surface to modulate the 2DEG.

I explained my idea to a colleague who was working on metalorganic chemical vapor deposition (MOCVD). He reasoned, however, that the structure I proposed was beyond state-of-the-art MOCVD at that time and declined to cooperate in growing heterostructures. I then introduced the idea to a coauthors' group, 7 August 1979, and obtained their cooperation in performing molecular beam epitaxy—the same growth technique used by Dingle. After some trial work, we succeeded in field-effect modulation of the 2DEG at the end of December 1979—the birth of what today is called the high electron mobility transistor (HEMT).

Since our demonstration of the HEMT, worldwide efforts to develop high-speed semiconductor circuits for supercomputers and low-noise amplifiers for satellite broadcasting and radio telescope systems[4] have been started. In addition to the technically significant device aspects, its potential application to basic science has proved significant—the quantized Hall effect was observed at lower magnetic fields[5] than those in silicon MOSFETs.[6] I was deeply honored to receive the Prize of the Minister of Science and Technology in Japan for the invention of the HEMT (1981) and to share the IEEE Morris N. Liebmann Memorial Award with S. Hiyamizu, one of my coauthors, for the demonstration of the HEMT (1990).

1. **Dingle R, Stormer H L, Gossard A C & Wiegmann W.** Electron mobilities in modulation-doped semiconductor heterojunction superlattices. *Appl. Phys. Lett.* 33:665-70, 1978. (Cited 560 times.)
2. **Mimura T, Tokoyama N, Kusakawa H, Suyama K & Fukuta M.** GaAs MOSFET for low-power high-speed logic applications. The 37th Device Research Conference, 25-27 June 1979, University of Colorado, Boulder, CO.
3. **Mimura T.** Japanese patent 1,409,643. 8 September 1987.
4. ---------- HEMT technology: impact on computer and communication systems. *Surface Sci.* 228:504-7, 1990.
5. **Narita S, Takeyama S, Luo W B, Hiyamizu S, Nanbu K & Hashimoto H.** Quantum galvanomagnetic properties of two-dimensional electron gas in $Al_xGa_{1-x}As$/GaAs heterojunction FET in strong magnetic fields. *Surface Sci.* 113:301-5, 1982.
6. **von Klitzing K, Dorda G & Pepper M.** New method for high-accuracy determination of the fine-structure constant based quantized Hall resistance. *Phys. Rev. Lett.* 45:494-7, 1980. (Cited 665 times.)

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