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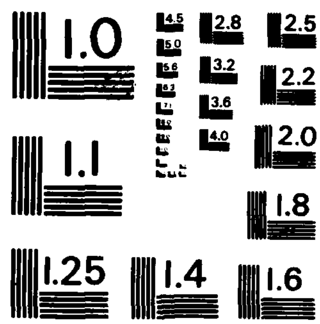

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R. R. Saxena et al., "Growth Studies of GaAs and AlGaAs by OMVPE", submitted to International Conference on Metalorganic VPE for Semiconductor Compounds, 4-6 May 1981; J. Crys. Growth 55, 58 (1981).

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The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Applications of atmospheric-pressure organometallic-grown GaAs-AlGaAs epitaxial (OMVPE) structures to potentially improved or new microwave FET structures were investigated. These included AlGaAs buffer layers for low-noise FETs, AlAs buffer layers for power FETs, and use of the selective etching of AlGaAs buffer layers to produce air-isolated FETs. The presence of increased trapping densities in the buffer layers, or surface states on the exposed channel layer in the case of the air-isolated structure, →

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) degraded rather than enhanced FET performance. Excellent performance was, however, obtained with conventional GaAs low-noise FETs grown entirely by OMVPE.

HEMT structures were also grown by OMVPE, but did not show the increased mobilities of identical structures grown by MBE. GaAs/AlGaAs structures analogous to silicon MOSFETs were also fabricated. Inversion of p-type substrates (n-channel operation) could not be obtained but, unexpectedly, indications were obtained of successful inversion of n-type material (p-channel operation).

BRIEF OUTLINE OF RESEARCH FINDINGS

Four main topics were addressed in the course of this work:

1. The use of higher-bandgap AlGaAs buffer layers to improve the characteristics of microwave FETs, both low noise and high power. A number of GaAs/AlGaAs/GaAs structures were grown and fabricated using a standard Varian low-noise FET mask set. No improvement in output conductance or FET performance was noted. The FET characteristics were light sensitive and "loopy", and it was concluded that the approach lacked promise. It was found possible to completely etch out the AlGaAs layer from below completed FETs, using citric acid, leaving them "air isolated". The channels were then substantially depleted from the underside by the surface states of the exposed GaAs. Although structurally impressive, these FETs too were light sensitive and had unimpressive electrical performance.

2. This investigation was briefly extended to power FET structures. Here it is desired to grow pure AlAs buffer layers, in order to take advantage of the high thermal conductivity of pure AlAs, and its expected high breakdown dielectric strength. These devices suffered from remote pinchoff, indicating substantial densities of shallow traps in the buffer layer, as well as light sensitivity, and it was concluded that the state of the art of AlAs growth and the difficulties of processing a moisture-sensitive structure made the approach less than promising.

3. The fabrication of 2-dimensional gas "HEMT" structures using the OMVPE growth method. Although we were able to show high electron mobility in MBE-grown structures, we were not able to demonstrate similar effects in OMVPE-grown structures, indicating a comparatively rough, or alternatively too gradual a transition at the critical GaAs/AlGaAs interface. These studies had begun with attempts to produce n-channel "MOS" devices on GaAs using AlGaAs as the "insulator". Inversion could not be demonstrated on p-type substrates, but surprisingly evidence was found for inversion on n-type substrates. By analogy with HEMT devices, this may indicate a high density of shallow acceptors in the AlGaAs. However, since p-channel devices on GaAs are of little interest, substantial effort was not put into verifying this conclusion, with the advent of very impressive HEMT performance.

4. DLTS studies. Excellent results were obtained using OMVPE-grown GaAs structures in submicron low-noise FETs. Performance was indistinguishable from the best MBE-grown FETs (Bandy et al., IEEE Electron Device Lett. 4, 42 (1983). Noise figures, however, were still higher than predicted by FET noise figure models, and it was concluded that the excess noise was due to rapid trapping and detrapping from shallow traps. DLTS studies were initiated on various OMVPE-grown materials. The following are typical of current 1.65-eV bandgap AlGaAs:

Trap energy	0.92	0.54	0.33	0.29-eV below conduction band
Concentration	1.4	11.0	9.6	1.3 $10^{13}/cm^3$
Cross sections		~1	~1	$10^{-20} cm^2$ at 300°K

Characterization of the still shallower levels responsible for microwave effects requires equipment not yet constructed.

Papers on the low-noise FET results and DLTS studies will be submitted for publication in due course.