Atomic Layer Deposition (ALD) Environmental Coatings for GaAs MMICs

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Introduction

Integrating ALD environmental coatings into the MMIC wafer fabrication process enables lower cost military systems than current systems with hermetic packages. This paper describes the work that was performed under a Title III project to optimize the ALD fabrication steps for two GaAs MMIC processes and release them for production at Raytheon's MMIC foundry in Andover, MA.

Integrated ALD Deposition

Raytheon utilized an ALD tool that was manufactured by Sundew Technologies. The existing silicon nitride coatings were replaced by two types of ALD coating. The new coatings perform all the original functions of the silicon nitride coatings plus provide resistance to humidity. The Cp and Cpk of these coating depositions are excellent.

	ALD 1	ALD 2
Wafer-to-wafer repeatability	Cp = 2.77 Cpk = 2.77	Cp = 2.66 Cpk = 2.59
Within-wafer uniformity	Cp = 4.02	Cp = 1.85

We achieved lower dielectric loading and better FET performance by substituting ALD coatings for the existing SiN coatings rather than adding an additional environmental protection layer on top of wafers fabricated with the old SiN process. The consistency of the deposition process also resulted in 2x tighter tolerances on capacitors and less variation in the RF properties of the FETs.

Environmental Test Results

A 96 hour Highly Accelerated Stress Test (HAST) at 130^{o}C and 85% relative humidity was used as a benchmark for the optimization of the ALD layers. The devices are biased at pinchoff during the test which is the maximum stress condition.

GaAs Process	Coatings	Bias	Failures
0.50 um optical gate FETs	SiN	11V	99%
0.50 um optical gate FETs	ALD	11V	2.7%
0.25 um ebeam gate FETs	ALD	7V	0.3%

The ALD FETs had a much lower failure rate than the original SiN FETs. Failure rates this low in a HAST test extrapolate to 100's of years of operation under worst-case natural conditions for ALD MMICs.

Conclusions

ALD dielectric layers are an excellent way to add environmental protection to GaAs MMICs without any increase in manufacturing cost. ALD MMICs enable the RF designer to attach MMICs to RF circuit card assemblies at a much lower cost than building traditional hermetic modules.

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