Novel Passivation Technology for GaAs PHEMTs

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Outline

- PHEMT Passivation: Current State
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- HD-ICP-CVD: A Novel Solution
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Passivation: Current State

- Silicon nitride (Si_xN_y) passivation is used on devices to prevent environmentally-induced degradation
- Currently, PECVD silicon nitride is widely used in GaAs PHEMT fabrication processes

Problem: Device Sensitivity

- For PHEMTs, device characteristics are very sensitive to passivation processes
  - PECVD nitride passivation incurs reduction in breakdown voltage [1]
  - Surface damage due to plasma ion bombardment can cause decreases in G_M and I_D [2]

[1] Chou, et al (2002), [2] Hattori, et al (1997)

Problem: Degradation

- Reliability is major concern in RF power GaAs PHEMTs
- Current passivation methods are not sufficient to inhibit device degradation
  - Presence of hydrogen induces degradation in GaAs PHEMTs [3]
  - Cracks in nitride allow for moisture path to devices, can cause circuit failure [4]

[3] Mertens et al, 2002. [4] Roesch, et al. 2000.

Motivation for Study

- An alternative deposition technique for passivating GaAs PHEMTs is needed
- Desire technique with the following:
  - incurs less change on device characteristics
  - improves device reliability
- Research reported by Chou, et al (2003) address this problem

Experimental

- **HD-ICP-CVD** (High-density inductively-coupled plasma chemical vapor deposition) system
- *Ammonia-free process* using only gaseous SiH_4 and N_2

Experimental

Parameters	PECVD	HD-ICP-CVD
Deposition Temp (°C)	250	170
Deposition Rate (Å/min)	~100	~500
Wet Etch Rate (Å/min)	600-1000	50-240
Gas Chemistry	$SiH_4/NH_3/N_2$	SiH_4/N_2
Hydrogen content (at%)	20-25	< 15

Results

- Less change in BV after passivation
- G_M, I_D decreases can be recovered by thermal annealing

Results

- Compared HD-ICP-CVD devices with two groups of PECVD devices
  - ∅ BV-F_T product is always higher for HD-ICP-CVD devices

Conclusions and Review

- Overall effects of HD-ICP-CVD:
  - less reduction in BV
  - allows for recovery of G_M and I_D
  - higher product of BV and F_T
  - provides better hermiticity

➔HD-ICP-CVD has good potential to be used for next-generation nitride passivation for GaAs PHEMTs