Newsletter
Research Activities of Semiconductor Companies

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FREESCALE SEMICONDUCTORS

Characterization of alterations on power MOSFET devices under extreme electro-thermal fatigue

**Abstract:** Extreme electro-thermal fatigue tests on power MOSFET-based switches for automotive applications have been performed in order to pinpoint their failure mechanisms. Contrary to devices from the former technology generation, the most important failure mode concentrates in the source metallization zone and consists in the degradation of the metallic layer. Intense intergranular and surface diffusion triggered by the thermal stresses between the Si substrate and the Al layer leads to intergranular crack formation. Around the ultimate life time (ULT) of the device, these intergranular cracks burrow almost down to the active transistor region and their density on the source surface is high enough to cause a loss of contact between the metal grains. The observed increase of the drain-source resistance could be attributed to this degradation that have qualitatively modeled. Observed melt down of the Al layer revealed by the formation of Al/Si eutectic could be the result of hot spots due to spikes in source resistance.

**Source:** Microelectronics Reliability

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HITACHI

Thickness evaluation of InGaAs/InAlAs quantum wells

**Abstract:** This work proposes a new optoelectronic measurement of quantum well (QW) thickness and applies it to doped and undoped In$_{0.53}$Ga$_{0.47}$As/In$_{0.52}$Al$_{0.48}$As multiple-QW structures. Near-infrared spectroscopic identification of the interband optical transition at 100–300 K gave the eigenenergies of the conduction band in the QW. Evaluation of the QW thickness involved analysis of the effective mass at the corresponding eigenenergy. QW thicknesses in the range of 5.45–20.8 nm were determined in six different wafers. These thicknesses agreed well with the QW thicknesses estimated by double-crystal x-ray diffraction within almost two monolayers. This measurement was used to determine the distance of potential boundaries confining the electron wave functions.

**Source:** Journal of Applied Physics

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KYMA TECHNOLOGIES

InAlN/GaN heterostructure field-effect transistors on Fe-doped semi-insulating GaN substrates

Abstract: InAlN/GaN heterostructure field-effect transistors (HFETs) have been grown and fabricated on Fe-doped semi-insulating c-plane GaN substrates. The problematic parasitic leakage caused by interface charge between the epitaxial layers and the GaN substrate as well as any adverse effect of the substrate surface damage caused by the mechanical chemical polish employed on the substrates has been circumvented by using a combination of inductively coupled plasma dry etching and in situ H₂ etching. As a result, the current leakage for 100 μm separation mesa-to-mesa was reduced down to 3×10⁻⁹ A/mm at 10 V voltage bias for a 320 μm mesa pad width normal to the current flow direction and the corresponding GaN buffer resistivity was about 3.5×10⁸ Ω cm. Owing to the good thermal conductivity of GaN substrates, the HFETs exhibit much less current degradation, compared to those on a sapphire substrate, at high drain biases. Likewise, the dc and pulsed I-V characteristics were reasonably similar, suggestive of negligible drain current lag. A dc saturation drain current density of 1.0 A/mm was achieved at zero gate bias. For HFETs with 1.1 μm gate length and 90 μm gate width, the maximum extrinsic dc transconductance was 275 mS/mm.

Source: Journal of Vacuum Science & Technology B

NTT

Photonic generation of continuous terahertz waves and its application to sensing and communications

Abstract: We show that photonic technologies developed for conventional fiber-optic communications have potential for use in contemporary terahertz-wave applications, such as remote sensing and wireless communications. Advanced unitravelling photodiodes (UTC-PDs) can produce output power of 0.5 mW at 350 GHz and 10 μW at 1 THz. Using the UTC-PD and other optical devices, we demonstrate a time-continuous terahertz-wave signal generator that can tune the output signal over a wide frequency range with very narrow spectral linewidth and gas-sensing with the terahertz-wave source. We also show some preliminary results for terahertz-wave wireless communications using photonic technologies.

Source: Proceedings of SPIE

ON SEMICONDUCTOR

Next generation of Deep Trench Isolation for Smart Power technologies with 120 V high-voltage devices

Abstract: A new Deep Trench Isolation (DTI) structure with high-voltage capability (BV > 150 V) and latch-up suppression (log(Ic/Ie) < -2 in adjacent pockets) is experimentally demonstrated in this work. The new DTI is implemented in a Nepi/BLN/N⁺/P⁺ Silicon stack by using a 0.18 μm CMOS-based platform. Moreover the advantages and design limitations of the new DTI are investigated by TCAD simulations and analytical models, being compared to its DTI predecessor in a Nepi/BLN/P⁺/P⁺ stack.

Source: Microelectronics Reliability
OSRAM OPTO SEMICONDUCTORS

N-face GaN nanorods: Continuous-flux MOVPE growth and morphological properties

Abstract : We demonstrate the morphological properties of height, diameter and shape controlled N-face GaN nanorods (NRs) by adjusting conventional growth parameters of a standard metalorganic vapour phase epitaxy (MOVPE) growth process. Particularly the hydrogen fraction within the carrier gas was shown to be an important shaping tool for the grown nanostructures. Additionally, the aspect ratio of the NRs was successfully tuned by increasing the pitch of the nanoimprint lithography (NIL) pattern, while maintaining the hole-diameter constant. An optimum aspect ratio could be found at pitches between 400 and 800 nm, whereas larger pitches are counterproductive. The major conclusion drawn from our experiments is that the whole amount of growth material available over the masked surface contributes to the growth of the NRs.

Source : Journal of Crystal Growth

ROHM

The low leakage current in floating body GaN metal oxide semiconductor field effect transistors

Abstract : Wide bandgap semiconductor based metal oxide semiconductor field effect transistors (MOSFETs) with an embedded p-type body layer (i.e., without grounding p-type body) was theoretically analyzed. In the GaN system, the reverse bias current density at the off-state, under applied 600 V at reverse bias region, was negligibly as small as 2.03 × 10⁻⁸ A/cm², even at the high temperature, 600 K. As a result, the variation in the potential of p-type layer was 0.26–0.52 V in the range of 300–600 K, i.e., negligible compared with the built-in voltage of the pn-junction (≈3.04–3.27 V). It is distinct consequence from cases of Si transistors, where the potential variation and leakage current were significant. This unique nature of wide bandgap material enables us to remove the contact to ground p-layer, which is beneficial in reducing device size, and thus on-resistance, significantly.

Source : Solid-State Electronics

SAMSUNG

The Effect of Passivation Layers on the Negative Bias Instability of Ga-In-Zn-O Thin Film Transistors under Illumination

Abstract : Ga-In-Zn-O(GIZO) thin film transistors (TFTs) with disparate passivation structures were fabricated and their stabilities were compared. The devices were subjected to a negative bias stress with simultaneous exposure to visible light. TFT that incorporates a dual passivation composed of a SiO₂ layer grown at a relatively high temperature with an additional SiN, film deposited shows only ~0.8 V 𝑉𝑖𝑛 shift, whereas a ~5.7 V shift was observed for a TFT covered by a single SiO₂ film. The device degradation is susceptible to the ability of protecting external moisture, which may adsorb on the surface of the GIZO semiconductor to create donor states therein.

Source : Electrochemical and Solid-State Letters
**Electrical characteristics and model for recessed channel fin field-effect transistor**

**Abstract**: The recessed channel fin field-effect transistor (RC-FinFET) has been developed as a future DRAM cell transistor. A recess-channel structure is applied to the FinFET to form a RC-FinFET. A three series-connected transistor model is proposed to understand the electrical characteristics. The RC-FinFET is considered to be a serial connection of three transistors consisting of one bottom transistor and two vertical transistors. The electrical characteristics of the RC-FinFET are compared with the normal FinFET and recessed-channel-array transistor (RCAT). The short channel immunity of the RC-FinFET is better than the normal FinFET and RCAT.

*Source*: Electronics Letters

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**SHARP**

**Polarity-controlled visible/infrared electroluminescence in Si-nanocrystal/Si light-emitting devices**

**Abstract**: We report the demonstration of a room-temperature visible/infrared color-switchable light-emitting device comprising a Si nanocrystal-embedded silicon oxide thin film on a p-type Si substrate. The device emits band-edge infrared light from the silicon substrate when the substrate is positively (forward) biased with respect to the Si-nanocrystal film. Under reverse bias, visible emission from the Si-nanocrystal film is observed. Compared to the photoluminescence of the Si-nanocrystal film, the visible electroluminescence is broader and blueshifted to shorter wavelength, and is ascribed to impact ionization in the Si-nanocrystal/SiO$_2$ film.

*Source*: Applied Physics Letters

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**SOITEC**

**New opportunities for SiGe and Ge channel p-FETs**

**Abstract**: A thin body (fully depleted) strained SOI device structure (FDSGOI), and a strained SiGe channel layer on SOI, were fabricated using scaled high-κ gate dielectrics and metal gate technology. The uniaxial strain effect and corresponding drive current enhancement reported by Irisawa et al. [1] for narrow-width devices was investigated on these structures. Although the strained FDSGOI device structure exhibited reduced off-state leakage compared to thicker body devices, and long-channel drive current enhancement under uniaxial strain, the loss of drive current enhancement at short channel length led to uncompetitive $I_{on}/I_{off}$ characteristics. The SiGe on SOI structure showed the highest long-channel drive current enhancement (nearly 3×) in the narrowest devices, and also showed a significant reduction in off-state current. This trend was maintained down to the shortest channel lengths studied here and resulted in $I_{on}/I_{off}$ characteristics that were competitive with contemporary uniaxial strained Si channel devices.

*Source*: Microelectronic Engineering

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**THALES**

**A 5000 h RF life test on 330 W RF-LDMOS transistors for radars applications**

*Abstract*: A reliability test bench dedicated to RF power devices is used to improve 330 W LDMOS in a radar conditions. The monitoring of RF power, drain, gate voltages and currents under various pulses and temperatures conditions are investigated. Numerous duty cycles are applied in order to stress LDMOS. It shows with tracking all this parameters that only few hot carrier injection phenomenon appear with no incidence on RF figures of merit ($P_{out}$ or PAE). Robustness and ruggedness are shown for LDMOS with this bench for radar applications in L-band.

Read more...

*Source*: Microelectronics Reliability

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**TOPGAN**

**Hole carrier concentration and photoluminescence in magnesium doped InGaN and GaN grown on sapphire and GaN misoriented substrates**

*Abstract*: Systematic studies of In$_x$Ga$_{1-x}$N layers ($0 \leq x < 0.13$) doped with Mg were performed. Samples were grown by metal organic vapor phase epitaxy. Intermediate Mg doping in the range of $2 \times 10^{19}$ cm$^{-3}$ was chosen to achieve a maximum hole carrier concentration, $p_H$ (as measured by Hall effect) of $4 \times 10^{18}$ cm$^{-3}$ in samples with high $x$. We confirmed reports on decreasing resistivity in In$_x$Ga$_{1-x}$N:Mg epitaxial layers observed with increasing $x$. This finding is very important for applications. In the performed research we attempted to separate contributions to $p_H$ increase resulting from increase in In-content and an associated decrease in growth temperature, $T_{gr}$ (necessary to obtain high $x$). For this purpose In-content increase was achieved by means of either (i) lowering the growth temperature (from 1020 to 830 °C) or by (ii) varying an intended GaN substrate miscut. We demonstrated that the increase in $p_H$ in In$_x$Ga$_{1-x}$N:Mg is caused by higher In concentration while a drop in $T_{gr}$ plays a secondary role. Studies of photoluminescence in the InGaN:Mg layers exhibit band-to-band radiative recombination which has created much controversy. The most important feature of samples grown at temperatures 860 °C and below, is a green band observed in InGaN:Mg layers (not in GaN:Mg obtained at the same $T_{gr}$) dominating the whole spectrum at room temperature. Its maximum shifts from 2.5 to 2.2 eV with increasing $x$ up to 0.13. Presence of this band was previously reported for InGaN:Mg. We present arguments that it originates from deep donor level.

Read more...

*Source*: Journal of Applied Physics

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