A Unique System Concept to Improve the Accuracy of Wafer-Level Flicker-Noise Characterization

Andrej Rumiantsev, Stojan Kanev
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SUSS Motivation

- Parameter extraction and statistical analysis are based on **Accurate** on-wafer measurement results:
  - DC (IV/CV) parameter
  - RF (S-) parameter
  - Low frequency noise (1/f)

- SUSS has to provide an invisible\(^1\) test environment to reach the best possible measurement **Accuracy**

\(^1\) Below the accuracy of the measurement instruments
Measurement **Accuracy** means:

- more efficient model extraction
- faster turnaround of the device models
- less design iterations
- faster time-to-market
- better return on investment (ROI)

→ SUSS helps you¹ to make more money

¹ With the best possible measurement accuracy
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Challenges for 1/f Measurements

- Noise is an unavoidable consequence of semiconductor technology.
- Since devices are becoming smaller and smaller, flicker noise becomes more important.
- Its impact on circuit performance is significant in today's low-voltage, high performance, mixed signal, RF, deep submicron designs.

The ability to accurately characterize noise becomes a fundamental requirement for design modeling!
Challenges for 1/f Measurements

**Accuracy**

- Passive system, Efficient shielding
- Manual prober
- Expensive EMI-shielded room

**Productivity**

- Big amount of data
- Automated system

New technologies do not allow compromises
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New Probe System Concept

Available 1/f Instrumentation:

• ProPlus solution w. 9812B and NoisePro software*

• Solution based on SR SR570 (current) pre-amplifier and Agilent IC-CAP**

* [NoisePro], ** [Blaum 2001]
New Probe System Concept

The benefits of the new concept:
1. Eliminates the need for the expensive EMI-shielded room
2. Improves measurement accuracy
3. Increases productivity
1. Expensive EMI-Shielded Room

Faraday cage for the DUT and all sensitive system components

No mechanical feed-throughs

→ Improved shielding efficiency
2. Measurement Accuracy

- Convert automated system into electrically passive manual station:
  - Turn off motors during the measurement circle
  - Lock the chuck position
- Improved grounding to avoid ground loops

→ Minimized AC noise

Picture: [Blaum, 2001]
2. Measurement Accuracy (cont.)

- The use of special ultra low-noise cables
- Reduced cable length

→ Optimized cabling
3. Productivity

- Automated measurement and parameter extraction
  - Integration with industry standard measurement and modeling software

- Measurement at different temperatures
  - Automated thermal management
1. **Pre-Amplifier** "*inside*" the EMI-shielded environment

2. **Shortest possible** low-noise triaxial cables for the Drain & Gate connection
EMI Shielding: ProbeShield

SR570 Pre-Amplifier ProbeShield “inside“ (battery driven): The same EMC\(^2\) Guard Option → different cables

- **Shortest possible** low noise cables for the low-pass filter
- RF pad design is recommended
Cabling: A Close Look

- Fully grounded probes are obligation
- Ground connecting close to the DUT
- Ultra low noise triaxial cables (part of EMC²Guard)
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EMI-Shielded Effectiveness

- EMI-certified test room
- Rohde & Schwarz EMI analyzer
- Measurements for different conditions:
  - Front
  - Rear
  - Side
EMI-Shielded Effectiveness (cont.)

EMI-shielded effectiveness $\rightarrow >25$dB from 1kHz to 70kHz
Experimental Setup

- SUSS PA300PS ProbeShield w. EMC² Guard option
- ProPlus solution
- Chamber Noise
- pMOS FET
- SiGe HBT
System Configuration

- Noise floor ~$10^{-24}$ A²/Hz
- 1 Hz...102.4 kHz (1MHz*)
Chamber Noise Verification using NoisePro Test

< -120dB
Verification with the DUT

- DUT type: pMOS FET
- Same bias conditions
- Same temperature conditions
- Old probe system configuration:
  - Preamplifier outside the EMI-shielded environment
- New probe system concept:
  - Preamplifier inside the ProbeShield EMC² chamber
Verification with the DUT

Old system concept (PreAmp “outside”)

New system concept (PreAmp “inside”)

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A. Rumiantsev, S. Kanev, MOS-AK 2008
Verification with the DUT

- DUT type: SiGe HBT
- New probe system concept
- Different bias conditions
- Different temperature conditions
Under different biases

TC = 25°C (ON)
$V_{CE} = 1.5V$
Bias 1 $\rightarrow I_B = 40nA$
Bias 2 $\rightarrow I_B = 500nA$
Bias 3 $\rightarrow I_B = 8\mu A$
Verification with SiGe HBT

Under different biases and temperatures

\( Ae/\alpha/\alpha_{bb}/T=10/10/10/25 \)

\( V_{CE} = 1.5V \)

Bias 1 \( \rightarrow \) \( I_B = 10\,nA \)
Bias 2 \( \rightarrow \) \( I_B = 40\,nA \)
Bias 4 \( \rightarrow \) \( I_B = 800\,nA \)
Bias 6 \( \rightarrow \) \( I_B = 2\,\mu A \)

\( I_B = 2\,\mu A \)
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New Probe System concept was introduced

• EMC² Guard
  – Save investment costs

• Increased measurement accuracy
  – More efficient modeling extraction

• System automation for unattended test
  – Faster time to data

• Turn-key solution
  – Seamless integration of the industry standard measurement and modeling solution (such as ProPlus)
References


