MULTI PROBE

Electrical Characterization of a Transistor using the Multiscan™ Atomic Force Probe (AFP)

Application Note AFP2-04

Electrical Characterization of Transistors

Discrete transistor probing has become an extremely difficult task as device feature size and pitch have shrunk. Moore's Law has driven transistor minimum feature sizes well below the limits of optically based probing. For standard 6T SRAM cell layouts, the cell area may be under $4\mu m^2$. This has forced analysts to resort to probing within SEM or FIB chambers and using the FIB to create probing pads at great expense. Expense, pump-down time, inflexibility, charged beam and noise associated with vacuum chambers make FIB or SEM based probing tools less than ideal. What is needed is a way to probe such structures using a tool that does not require construction of probe pads and difficult sample preparation nor exposes the sample to charged beams. The results below demonstrate that the Multiprobe AFP is capable of performing these measurements.

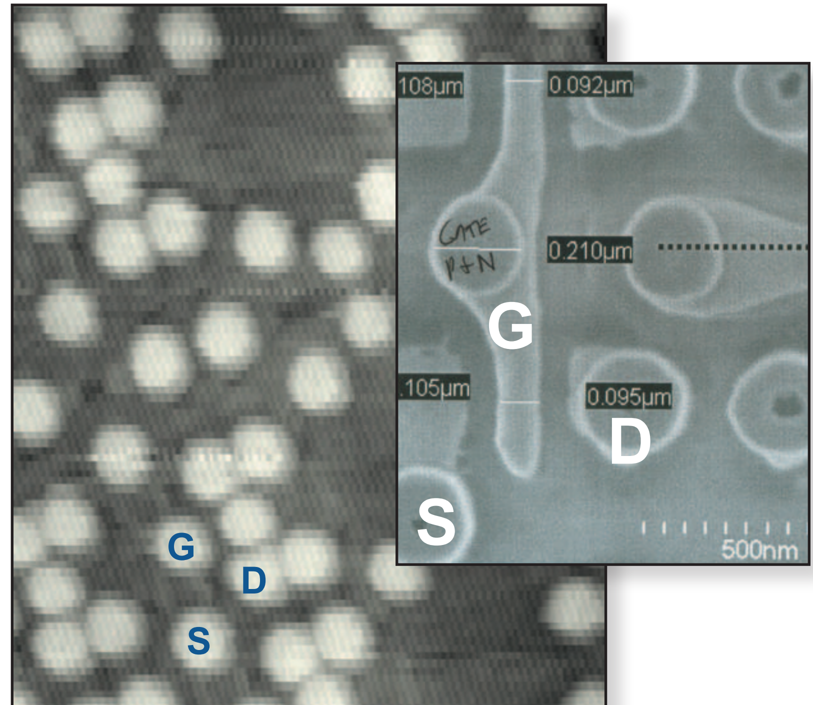

Figure 1: SEM micrograph (top) and AFP image (bottom), showing the tungsten contacts and poly gate finger of the N channel transistor within the SRAM array that was probed in this analysis. The gate length is 90nm and the width is 300nm. The contacts are about 210nm in diameter with a minimum pitch of 300nm.

Micrographs

Figure 1 shows an AFP micrograph with labels on the Source, Drain and Gate of the transistor probed in this application note. Also in figure 1 is a SEM image of the sample etched to show gate length poly critical dimension (CD) of 90nm.

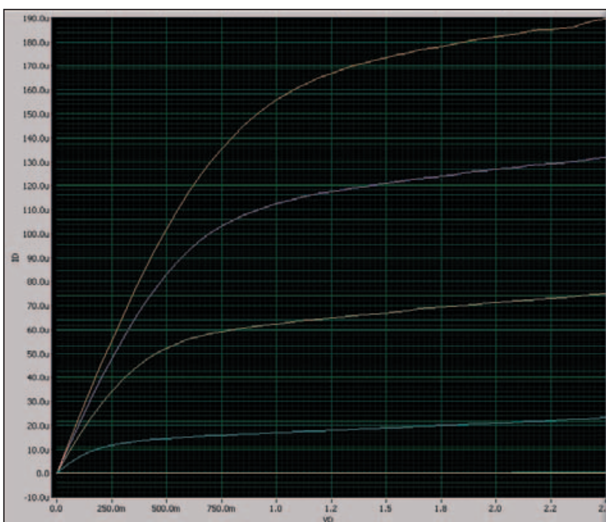

Figure 2: Ids vs Vds Family of Curves for the above 90nm transistor. Vgs from -0.5 to 2.5V in 500mV steps. Curves were acquired using an HP4145B connected via GPIB to Multiprobe acquisition software.

Family of Curves

Figure 2 shows the family of curves with Drain to Source current: Ids vs Vds at different Vgs settings.

V^{th} and I Drive

Figure 3 is the measurement of threshold and current drive for the same transistor where the gate and drain voltages are tied together at the measurement tool and swept together. The data is also displayed in Logarithmic plot to show sub-threshold characteristics with currents down to pico amps.

Sample Preparation

The sample preparation required for these measurements was simply a parallel lapping to remove the metal layers and then a brief etch using Buffered HF 5%. The sample was not exposed to a charged beam and therefore the measurements do not suffer from threshold voltage shifts due to charging.

The Atomic Force Probe (AFP) is an ideal tool for imaging and contacting deep submicron structures.

The sharp probes, nano-positioning using piezo electrics, and force feedback provide the user with a nanometer resolution map of surface structures and the ability to place the probes on the desired nodes very quickly with controlled contact force. The AFP is designed to use ultra-sharp tungsten needles to give the probes a tremendously long lifetime for both imaging and probing effect. The current on all contacts is orders of magnitude higher. It would be expected that the IV characteristics of such a transistor would be adversely affected. However until the introduction of the AFP, it would have been nearly impossible to carry out such a study.

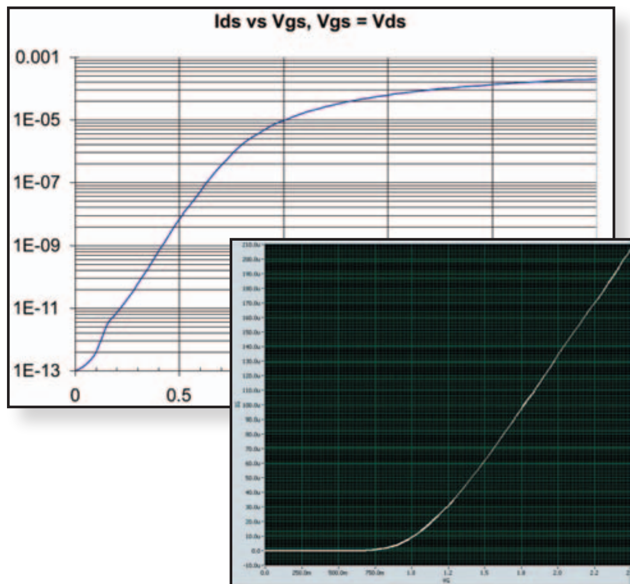

Figure 3: Threshold Voltage IV curves with Gate and Drain voltages tied together. The log plot (top) shows the sub-threshold current and the linear plot (bottom) shows the turn-on current drive capability

How to achieve these results

Gross Position

Use the optics and mechanical positioners to bring a probes to within roughly 5μm of probing target.

Image

Patent Pending Multiscan™ software scans all probes simultaneously, saving time and raising productivity.

Identify nodes

Probe by placing a cursor on the contacts in each image. The software identifies the offset and position of each probe.

Probe

Multiscan™ lets you apply the force required to make ohmic contact with force control orders of magnitude finer than the best positioner. Control of the contact force means the probes stay sharp.

Measure

AFP keeps the probes contacting the nodes for the time required to perform the electrical characterization.

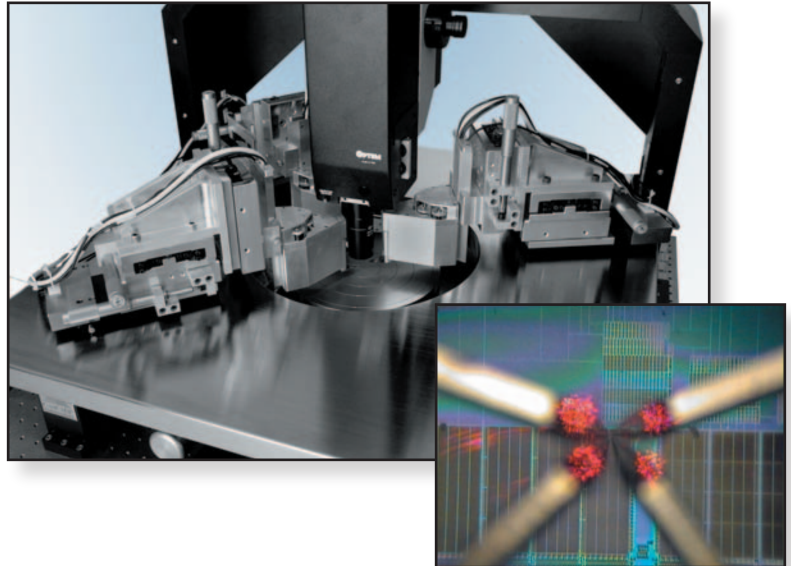

Figure 4: Atomic Force Probes (top). Optical Micrograph of 4 AFP Probes positioned over a 90nm sample (bottom).

Technology node	65nm
Contact Pitch	0.25µm
Placement accuracy	<10nm
Image Resolution	<50nm
Image acquisition time	~minute
Probe Placement time	~minute
Probe Lifetime	1000's of contacts*
Maximum scan size	35µm
Contact Resistance	<100Ω
Force Control	1000X**
Optics Compatibility	SL100 or AZoom
Station Compatibility	X4 or DSM Station***
Noise Floor	1nm

*Verified by contact scanning
** Max force/imaging force
*** Specs above with Cascade DSM station

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