

The Bruker SCM test sample

This document describes the SRAM test sample that is supplied with the SCM sensor (application module). This sample will enable you to become familiar with the SCM technique and also provides a known sample that will aid in diagnosing problems with the system.

The SRAM samples are test structures that are processed as far as metal 1. The sample as supplied has subsequently been de-processed to bare silicon with the metal 1 and oxide layers stripped in hydrofluoric acid. Prior to shipping, the samples are mounted to metal pucks using silver loaded epoxy from Dynaloy (Dynaloy 325). After curing for one hour at 75°C the samples are heat-treated in air for approximately 15 minutes at 325°C. This process provides a more uniform dielectric layer than native oxide alone and enhances the p/n contrast in SCM mode. During the last 30 seconds of the heat treatment the samples are subjected to illumination from a short wavelength UVC light source in order to remove any trapped charge at the surface layers.

The SRAM will have a variety of topographical features relating to implant regions and these will vary from sample to sample depending upon where on the wafer the piece was taken from. Regardless of this there will be an area of the sample that has the required implant pattern. This implant pattern is described later and is shown in [Figure 1](#), as seen with the optics of the Dimension Icon microscope.

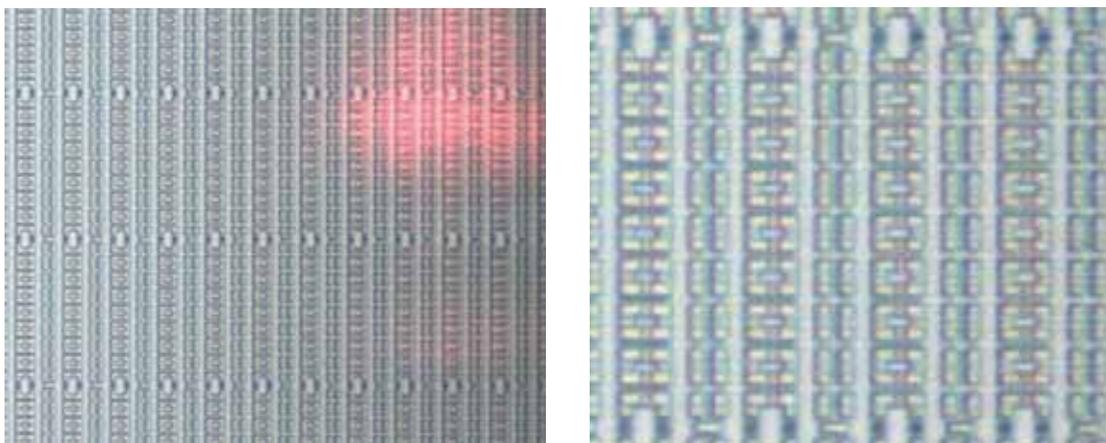


Figure 1 Optical image of the SRAM sample.

With the Dimension optics in high zoom mode the implant NMOS and PMOS islands are clearly visible. An area that is free from surface contamination is preferable; the surface may be cleaned with replicating tape if required (Ted Pella, Prod No. 44840).

The basic structure of the SRAM, as measured with the AFM is shown in [Figure 2](#). The left-hand image shows the topography for a 30µm scan while the associated SCM data is shown on the right. The default parameters for imaging the sample are discussed in the

SCM section of the application modules manual. The SCM data presented here is the data type **SCM Data**.

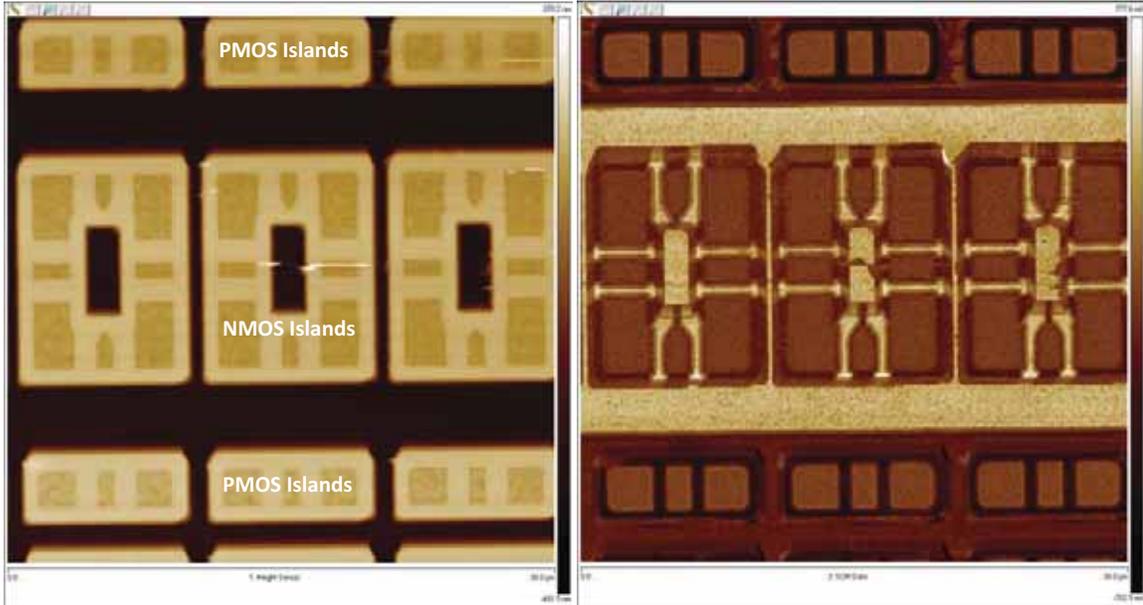


Figure 2 SRAM sample showing the topography, left and the SCM Data, right.

The AFM topography reveals implant regions of the sample and shows the PMOS and NMOS structures but yields no information about dopant levels. The SCM data shows both the type and level of dopant at each point on the sample. The dopant type for these structures is shown graphically in [Figure 3](#), with values for the dopant levels given in [Table 1](#).

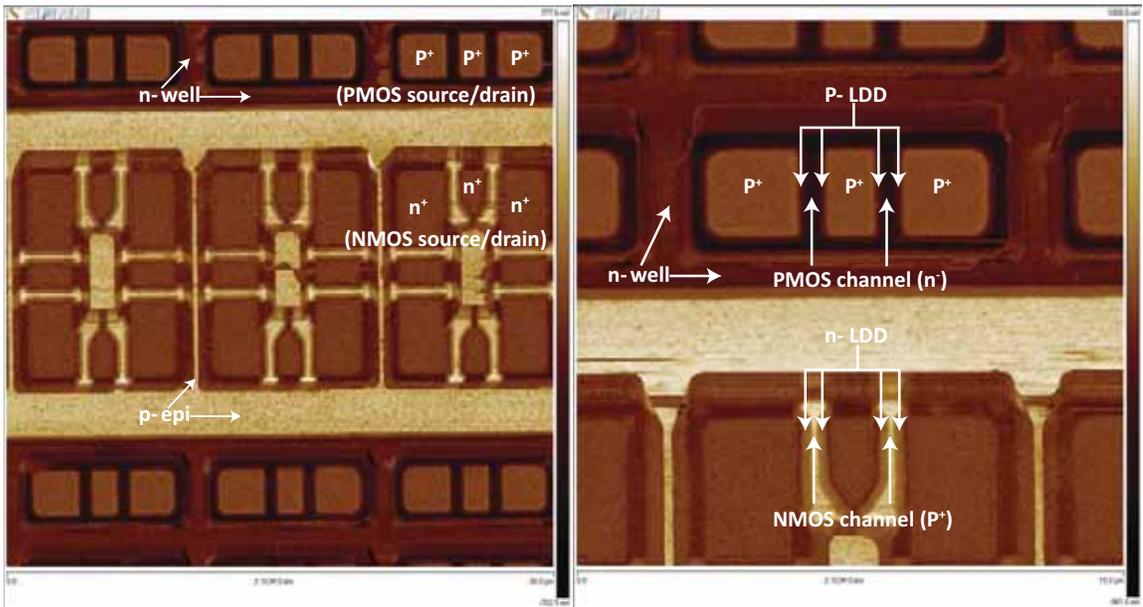


Figure 3 Specifications of the SRAM.

TABLE 1. SRAM specifications.

	Type	Concentration (cm ⁻³)	Species	Dose (cm ⁻²)	Energy (KeV)
p-epi	p	2x10 ¹⁶			
n-Channel	p	2x10 ¹⁷	BF ₂ ⁺	2x10 ¹²	30
n-LDD	n	5x10 ¹⁸	P ⁺	6x10 ¹³	40
n ⁺	n	2x10 ²⁰	As ⁺	4x10 ¹⁵	100
n-Well		2x10 ¹⁷	P ⁺	1.7x10 ¹³	900
p-Channel		1x10 ¹⁷	P ⁺	1x10 ¹²	175
p-LDD		3x10 ¹⁸	BF ₂ ⁺	6x10 ¹³	40
p ⁺		4x10 ¹⁹	BF ₂ ⁺	2x10 ¹⁵	45

The SCM sensor measures the $\delta C/\delta V$ signal as the carriers are depleted and accumulated under the influence of the applied ac bias. This signal is mapped to a color table and displayed within the NanoScope software. If the sensor is configured as described in the application modules manual then the color table will map dopant as shown in [Figure 4](#). N-type material will show a negative (darker) color while p-type will be positive (lighter). Lower doped material, being easier to deplete, will yield a higher $\delta C/\delta V$ signal (lighter with color palette 12) than heavily doped material of the same species.

Note: It is possible for the system to be configured so that the displayed data is 180 degrees out of phase with the color table shown. This is not a fault with the system and equally valid data is obtained. For this reason care should be taken when determining the dopant type.

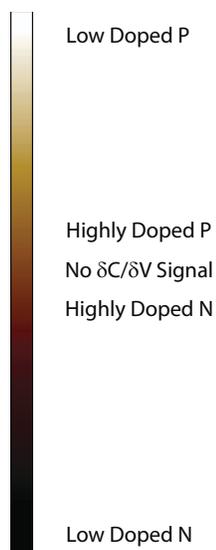


Figure 4 The Color bar associated with SCM Data (palette 12).

The data will show two distinct implant regions of the sample. These regions consist of n-type implants into the p-epi layer and p-type implants in the n-well. These implant regions should be readily identifiable on a 15 μ m scan of the sample, shown in [Figure 5](#).

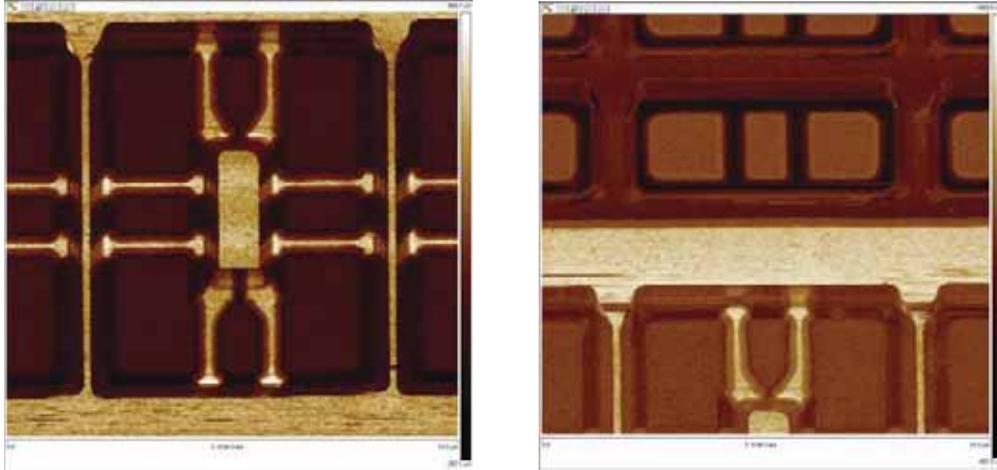


Figure 5 SCM Data for NMOS (left) and PMOS (right) implant regions with zero applied DC bias.

The implants for both structures show pn junctions with associated LDD regions. These can be clearly seen in the images of [Figure 5](#) as dark bands, n-type and light bands, p-type.

The n-LDD region of the sample provides a region that has both n and p-type material in close proximity in the form of an npn device. This region is shown in SCM Data as [Figure 6](#). The data shown is from a 4 μ m zoom of a 15 μ m scan of a portion of the NMOS device regions. The SCM image clearly shows the p-epi, (purple) the n-channel (p-type) and the n implants with their associated LDD regions. It should be noted that the lower doped region of the LDD gives a higher $\delta C/\delta V$ signal than the rest of the n-type implanted region. This is displayed as a dark band with the default color bar, palette 17, used here.

The width of the LDD region is large by current technology standards but serves to demonstrate the type of data that can be expected from the LDD region of a device. The LDD region would be harder to locate if the sample were imaged in cross-section, as its geometry is considerably smaller in this orientation.

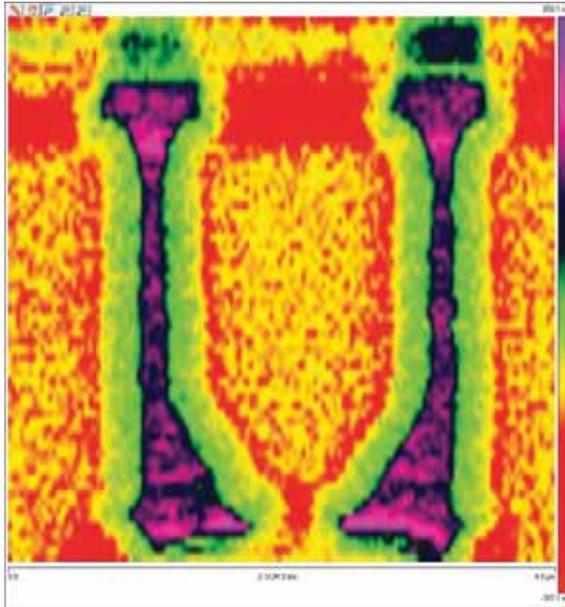


Figure 6 SCM Data of one of the LDD regions.

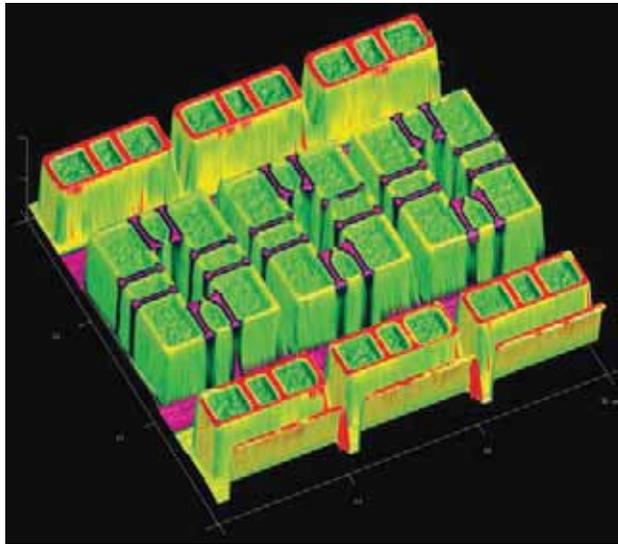


Figure 7 3D image of Height channel with SCM Data superimposed.

The application of a DC bias to the sample will have the affect of depleting or accumulating carriers in the sample. This will show in the data as a shift in the position of the pn junction along the color scale.

If a positive DC bias is applied to the sample then the p-type material will undergo accumulation. This makes it more difficult to deplete this type of dopant and hence the $\delta C/\delta V$ signal will decrease. If sufficient DC bias is applied to the sample then it is possible to reverse the contrast of the $\delta C/\delta V$ data on the color table. Conversely if a negative DC bias is applied to the sample n-type material will accumulate and p-type implants will undergo depletion.