BRIEF UPDATE ON SiPM-ARRAY PROGRESS

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This is a brief report on the latest developments at SensL based on my working trip there on July 16th. As a reminder, we were expecting six arrays of 12 x 3mm x 3mm cells as close out of Phase 1 of the R&D contract. The arrays recently fabricated by SensL had two new developments in their construction, compared to the first working prototype now at the UofR:

1. The Si used incorporated the latest improvements in DR reduction with a nominal 600 Hz per 20 μm pixel.
2. The flex was redesigned to remove the four corner dies and the flex thickness was increased to 100 μm thick in order to increase rigidity and improve cell dimensional uniformity within the matrix. Other design changes included the increase of the metal landing pad on the flex from 100 x 100 μm to 200 x 100 μm to ease the lateral alignment problems faced with the earlier assembly.

1. SiPM arrays based on flex technology

Figure 1 shows the SiPM arrays based on A20L 1mm SPM devices assembled using flex technology. The arrays were successfully assembled by flip-chip thermo-compression bonding using gold stud bumps. The arrays were mounted on glass carrier slides for testing purposes. Testing involved an IV sweep to test electrically the leakage and breakdown characteristics of the array. All six arrays tested showed no IV characteristics other than that of the gold leads. SensL is currently investigating, in collaboration with their assembly manufacturer, the reasons why these arrays failed. The build Si used in this construction had exhausted the supply of available detectors, which showed improvements in the DR. On a positive note, the thicker flex sheet did greatly improve the geometrical uniformity of the array matrix.

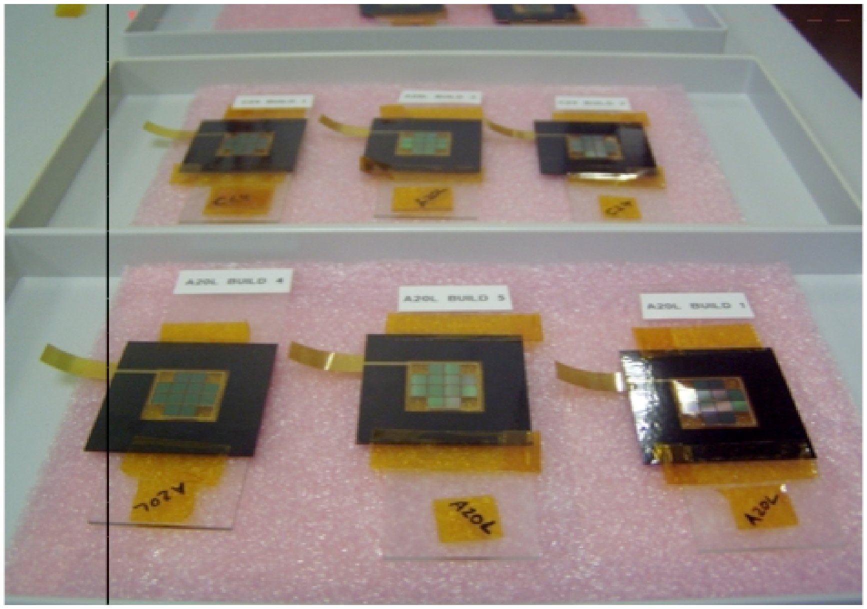

FIGURE 1: The six 12-element SiPM arrays mounted on flex.

2. SiPM arrays based on glass technology

During our last meeting at SensL in February 2007, the idea of using glass as the mounting surface, instead of flex, had been discussed as a next development. Glass has certain advantages, such as rigidity and strength as well as a smooth surface. For the BCAL read out, either flex or glass can be used without any effects on performance. SensL has now produced arrays on glass and one of them was tested for the first time during my stay there on July 16th. The text and figures below reflect solely the testing and results of the glass version of a 16 x 3 mm x 3 mm array.

The cell structure of the array was of the A50H design. This uses 50 μm pixels (square) that result in high fill factor but the DR reflects the larger area and the older generation of DR improvements. Therefore, further testing and measurements of this specific array should be corrected for active area - when DR and PDE are extracted. The testing at SensL addressed two critical performance aspects only, that of the uniformity of breakdown voltage among the cells, as expressed in the IV curve, and the electrical integrity in the number of cells that contributed to the IV curve. Figure 2, below, shows a photograph of the glass-mounted array before any wires were connected for testing. The glass slide the array is mounted on is barely visible and the glass slide above it is there simply for protection during manipulation, thus giving the illusion that the array is not aligned with the glass slide. The blue film protects the active side of the array against damage by handling.

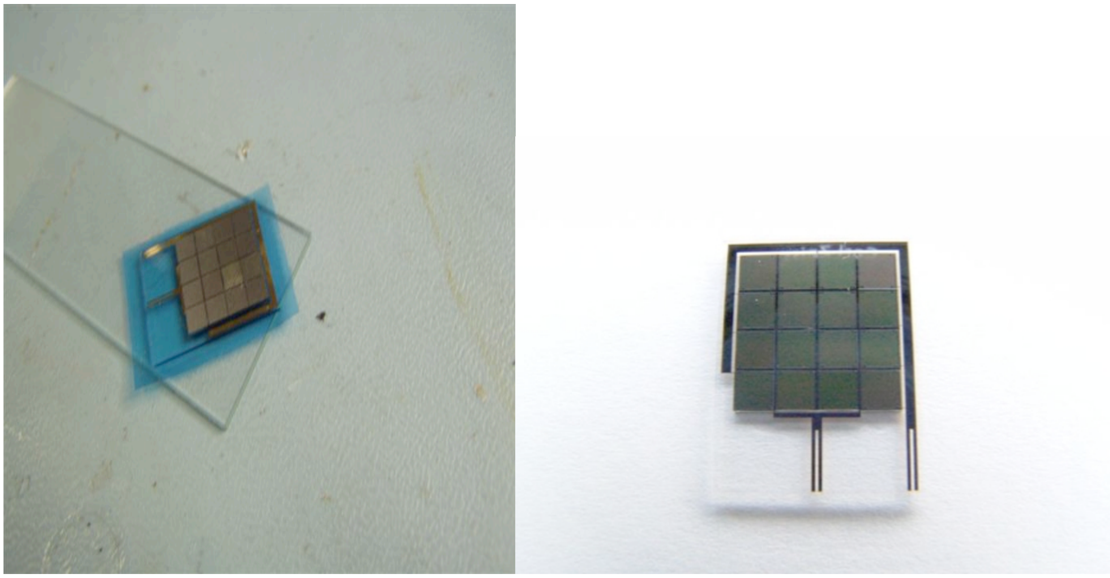

FIGURE 2: The 16-cell array before testing and a close up showing the leads.

In order to test the response of the cells to light, electrical contact in the form of two electrodes had to be soldered onto the gold contacts. This was done under the skillful soldering of Andrew Stewart without melting the protective blue plastic film! The result is shown in Figure 3, below:

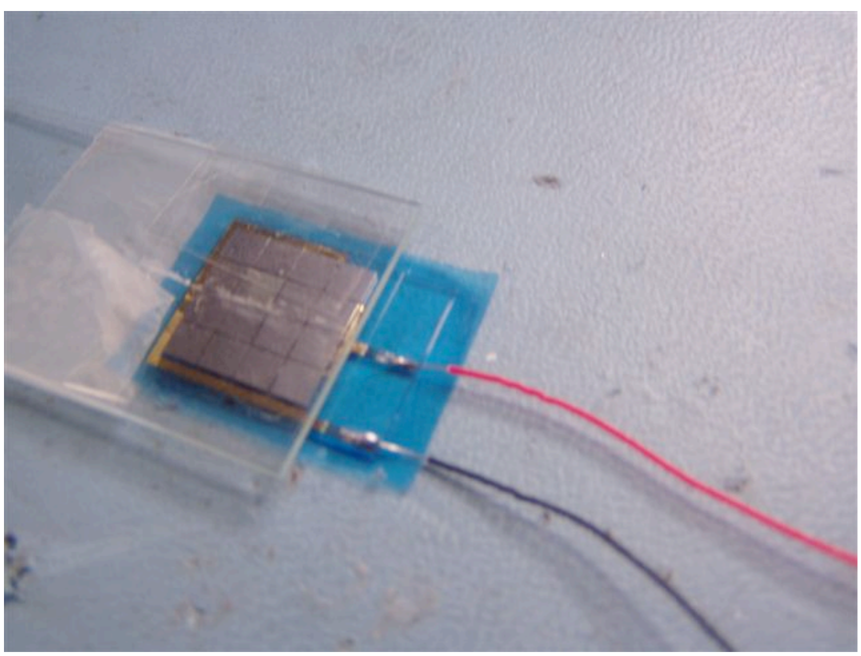

FIGURE 3: The array with wires already soldered to it and ready for testing.

The IV curve of the array can be measured by a simple cold probe contact. SensL had indeed measured the IV curve that way and the result was an impressively sharp definition of breakdown voltage. This can either mean that all active cells have the same breakdown voltage or that only a few cells are actually contributing. In order to test the latter, electrodes had to be attached and the array was placed in a measuring apparatus that allows an LED source to shine light on individual cells to test for electrical integrity.

Figure 4 show the IV curve as measured with both cold and hot contacts. One curve is the result of the soldered wire measurements while the other is with the probe. Both measurements are done in a dark box without a light source and in effect they measure dark current (DC). Both curves, but particularly so the soldered-wire measurement, show a very sharp definition of the breakdown voltage onset at 27.5 V.

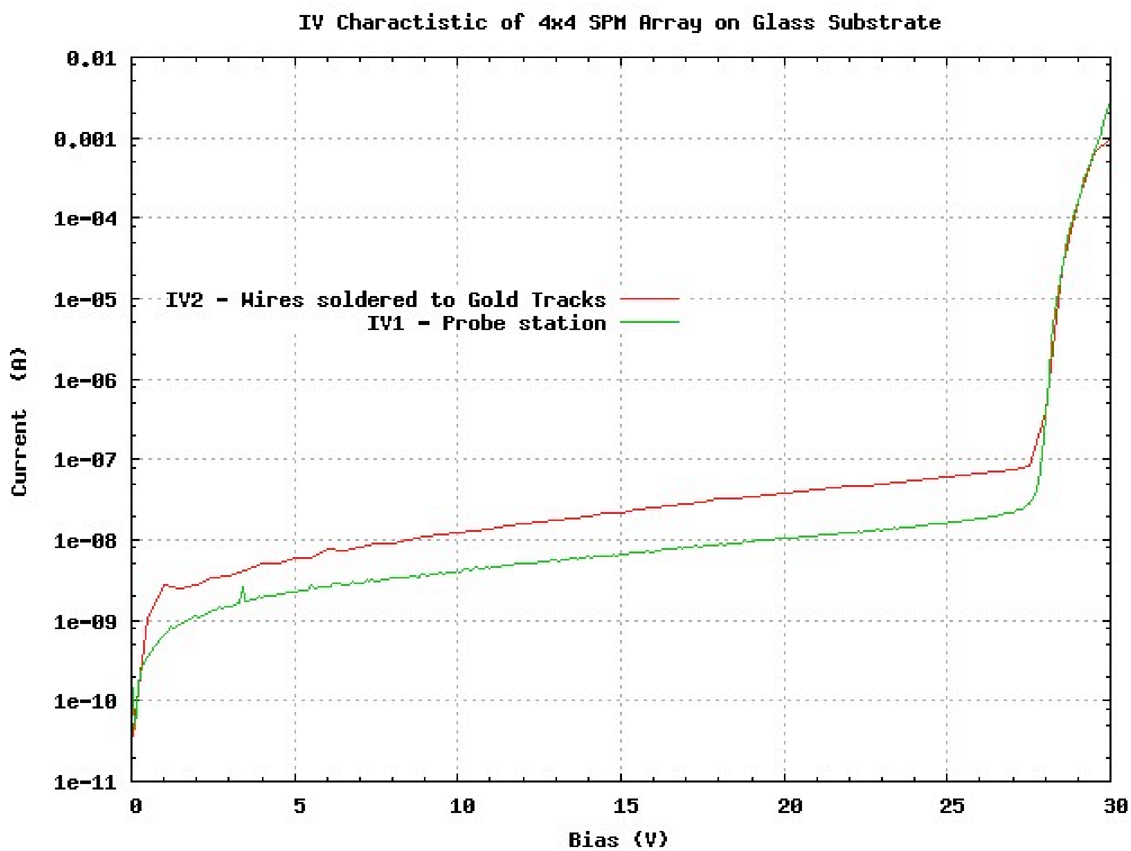

FIGURE 4: The two IV curves for probe contact (green) and soldered contacts (red), respectively.

The array was then placed in a (mostly) dark box, connected to an electronics board - of the type used for the 1mm x 1mm and 3 mm x 3mm arrays from SensL - and individual cells were illuminated by a blue LED source and a fiber optic wire and the array was scanned placing the light spot on each cell successively and observing the response on an oscilloscope. The latter was triggered by the pulse generator driving the LED to verify that the cell response was due to the LED light incident on it. All 16 cells were found to be electrically active, with each responding to the incident light source. Due to the tape used to hold the array on the stand and the "crude" mounting arrangement, the pulse height from each array cannot be used as a gauge of uniformity of response. This is best accomplished with the new laser system that we just received at the UofR. Figure 5 shows the pulses from the array and the their correlation to the pulse generator driving the LED.

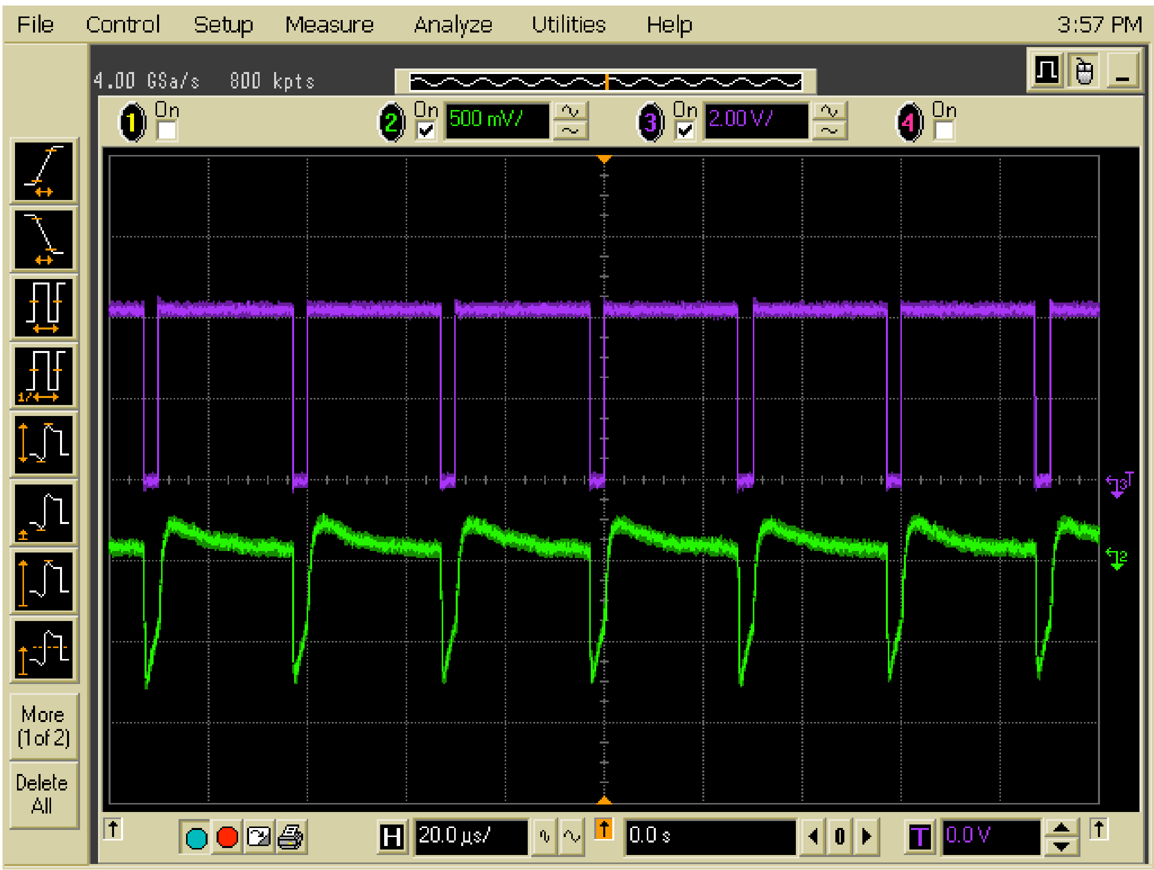

FIGURE 5: The LED trigger pulses (purple) and the array output (green).

Based on the above developments, it was decided that the conclusion of the Phase 1 contract will be accomplished with arrays on glass of the type above. This will prove the proof of principle, allow extensive testing and better define the Phase 2 protocols and expectations while the DR and pulse decay time issues are being addressed by SensL and incorporated in the Phase 2 deliverables. The expected delivery of the six glass mounted arrays is now estimated on week #35, in other words 4-6 weeks from the time this is written.