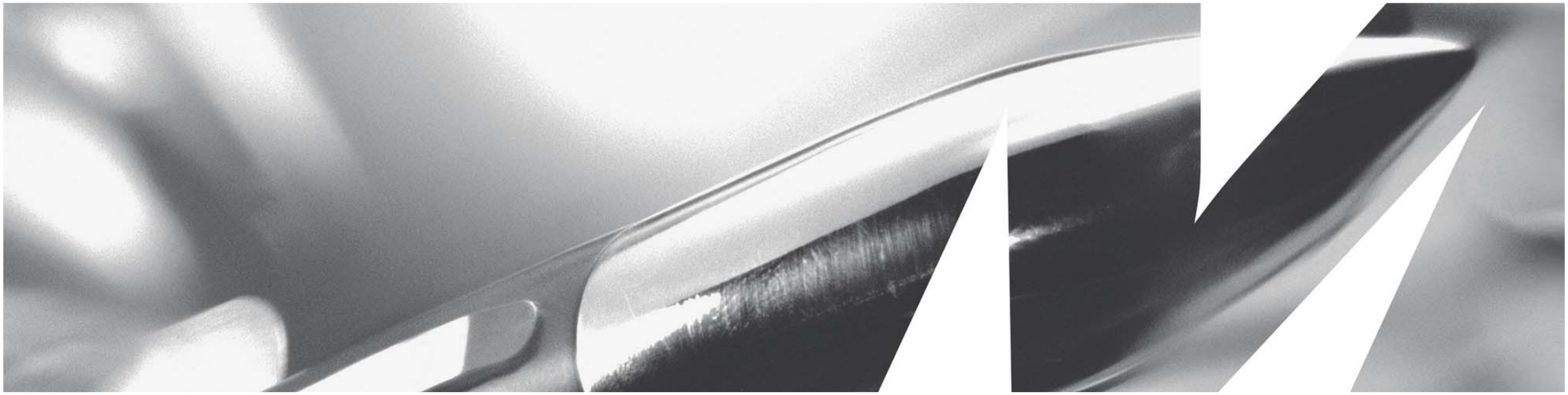

Improvements of laser bench test set-up and its validation by testing memories

Prepared by Andrew Chugg, Jonathan Ward & James McIntosh

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COO 5 under ESTEC Contract No. 16916/02/NL/PA:
Investment in the Utilisation of Pulsed Lasers for SEE Testing

CNES/ESA final presentation days: 16:10, 29 March 2011
Location: ESTEC/ESA, (The Netherlands), Escape Dance Hall

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Introduction

- Relationships between SEREEL2 Investment Activities and Laser SEE Testing Capability Improvements
  - Revised Labview positioning system
    - Continuous, low acceleration scanning patterns
    - High reproducibility
  - Automation of SEU & SEL sensitivity mapping in 3D
    - SEE sensitivity mapping of microchips in up to three dimensions
    - New STREAMlite memory test card with memory patch targetting
- Validation Activities
  - Upset Sensitivity Mapping
    - Inter-cell and intra-cell laser SEU sensitivity mapping
    - Automated memory address descrambling
  - Backside Pulsing (e.g. 2-photon)
    - Backside pulsing is increasingly important due to obscuration of the front faces of microchips by metallisation, ball grid arrays…
    - The 2-photon technique provides an efficient approach, but ~1064nm single photon remains viable

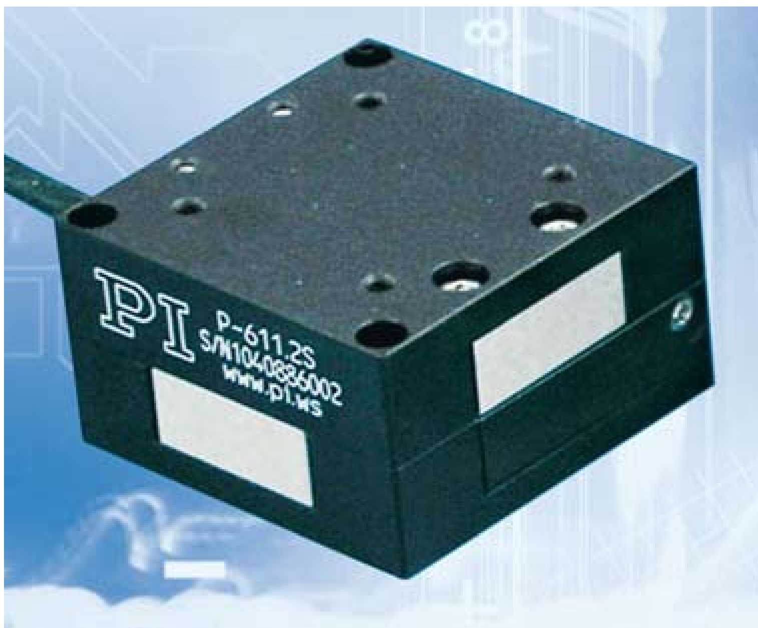
Stepper motor versus piezo-electric positioning systems compared

Stepper Motor Positioning System	Piezo-Electric Positioning System
Only a square grid of laser pulse positions	Delivers a wide variety of trajectories in x-y smoothly
Uses raster scanning patterns	Rasters and also spiral trajectories etc.
Accelerations (jerks) at the end of each row	Sharp accelerations are unnecessary and acceleration in general can be made arbitrarily low
Induced vibrations in the mount so exact locations of laser pulses unknown	Arbitrarily low vibration makes laser pulse arrays reproducible at precisely the same points – key enabling factor for 3D sensitivity mapping
The deceleration at the end of each line yields clusters of laser pulses at the array edges, since the laser pulsing rate is fixed	Can Deliver a perfectly evenly spread array of pulses (no clustering)

Piezo Actuated Positioning System – progressing beyond stepper motors!

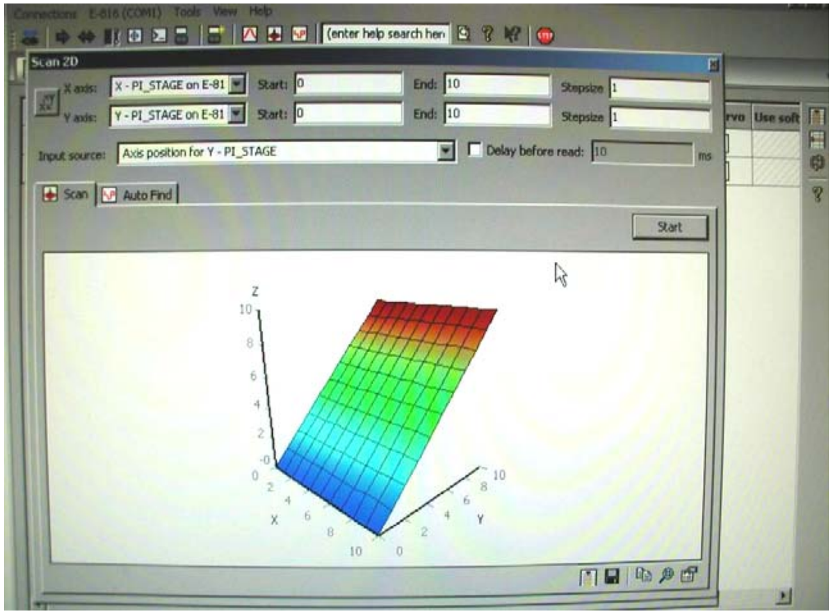
XY Nanopositioning system:
2-axis compact piezo system for nanopositioning tasks.

Piezo servo-controller and driver:
compact bench top device with high speed interface.



Piezo Actuated Positioning System

- Utilisation and testing of the piezo stage began with the Physik Instrument (PI) Mikromove software (supplied with the system)



- Following on from preliminary work the piezo stage development continued within the LabVIEW programming environment, facilitating integration with the existing control software, also re-developed

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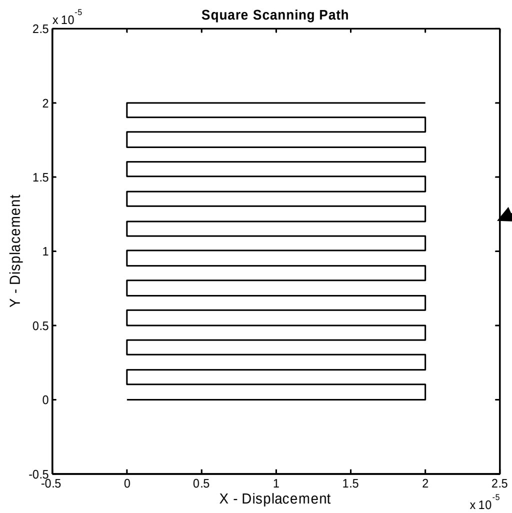
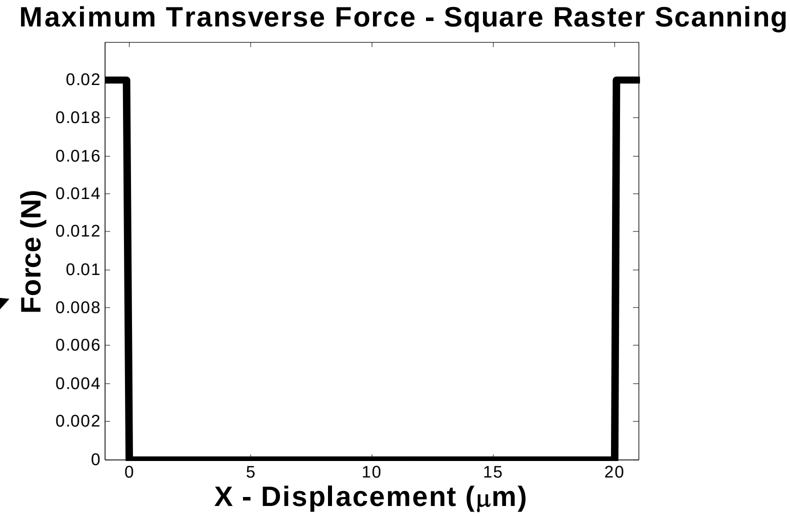
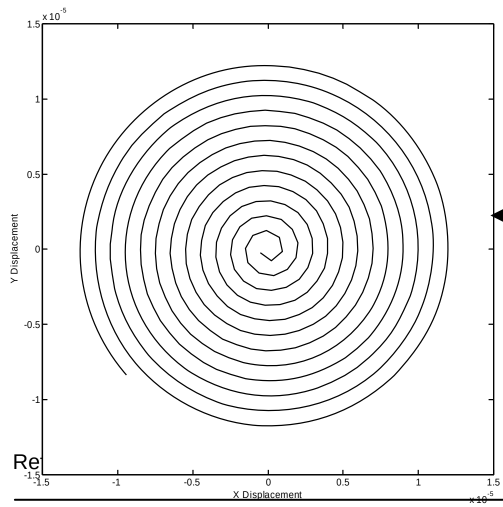
Force/acceleration minimisation

- Minimising the force on the system due to acceleration of the DUT to improve the positioning accuracy and avoid reverberation

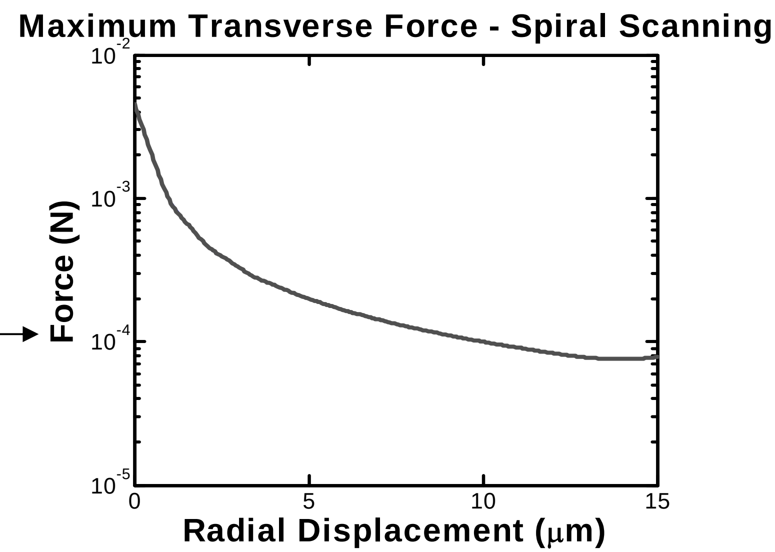


Square raster scanning path





Spiral scanning path



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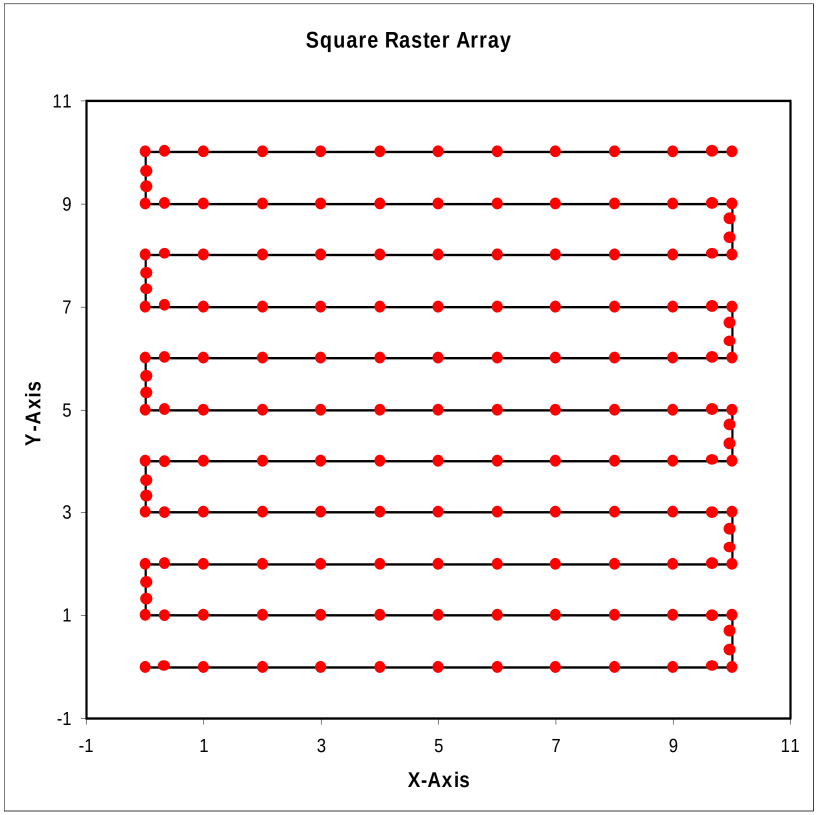
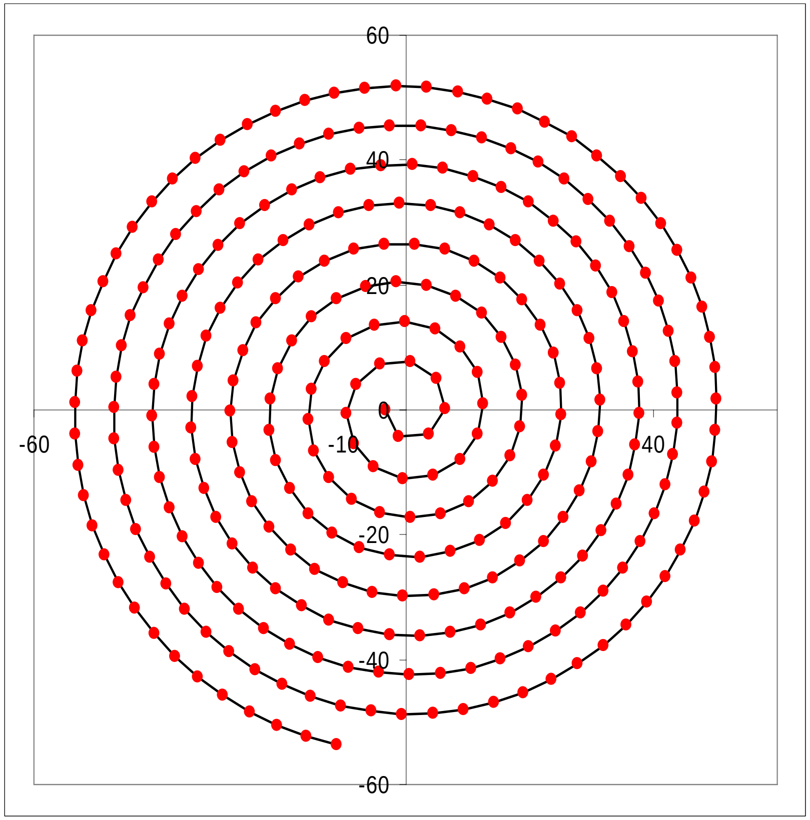
How the spiral trajectory achieves a more even distribution of laser pulses





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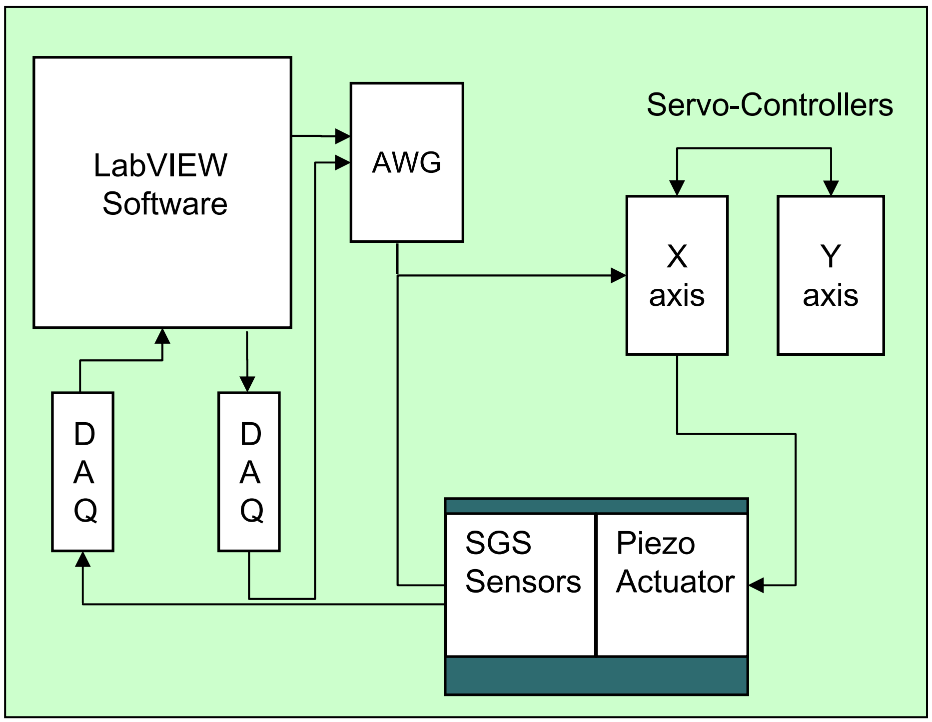
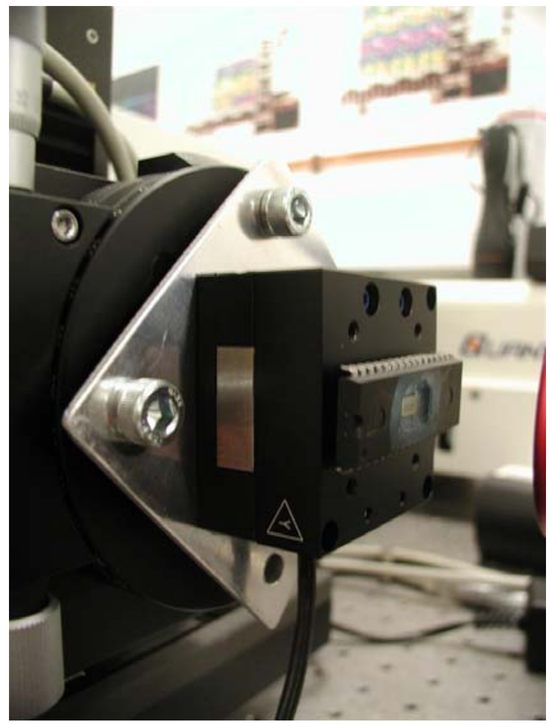
Piezo-Actuated Positioning System Configuration

- Feedback configuration of the piezo positioning system
- Strain Gauge Sensors provide feedback on actual position of the system
  - for comparison with the intended (mathematically defined) position





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Raster pattern motion of a microchip under piezo-electric positioner control

- Raster scanning was used to demonstrate the functionality of the piezo-electric x-y actuation system in the SEREEL2 positioning system
- Rasters are particularly applicable for (fine scale) descrambling

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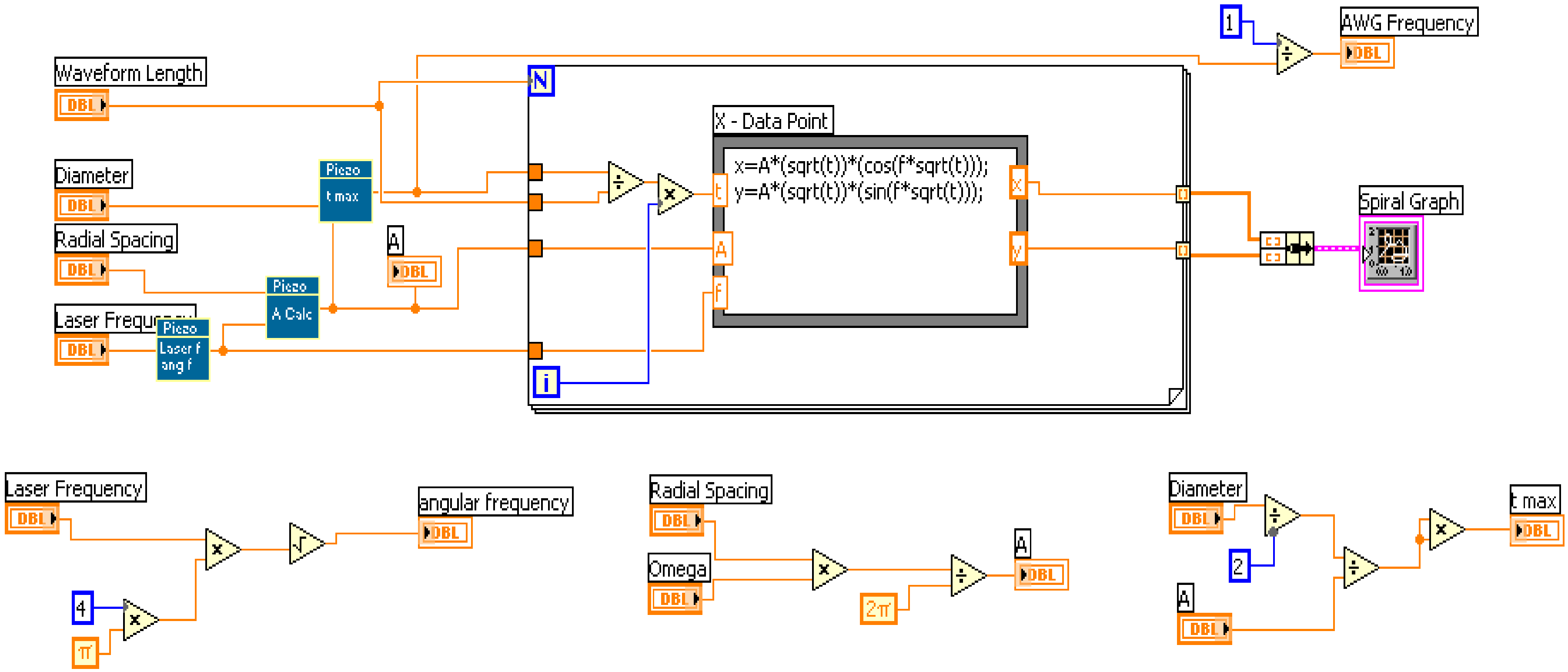
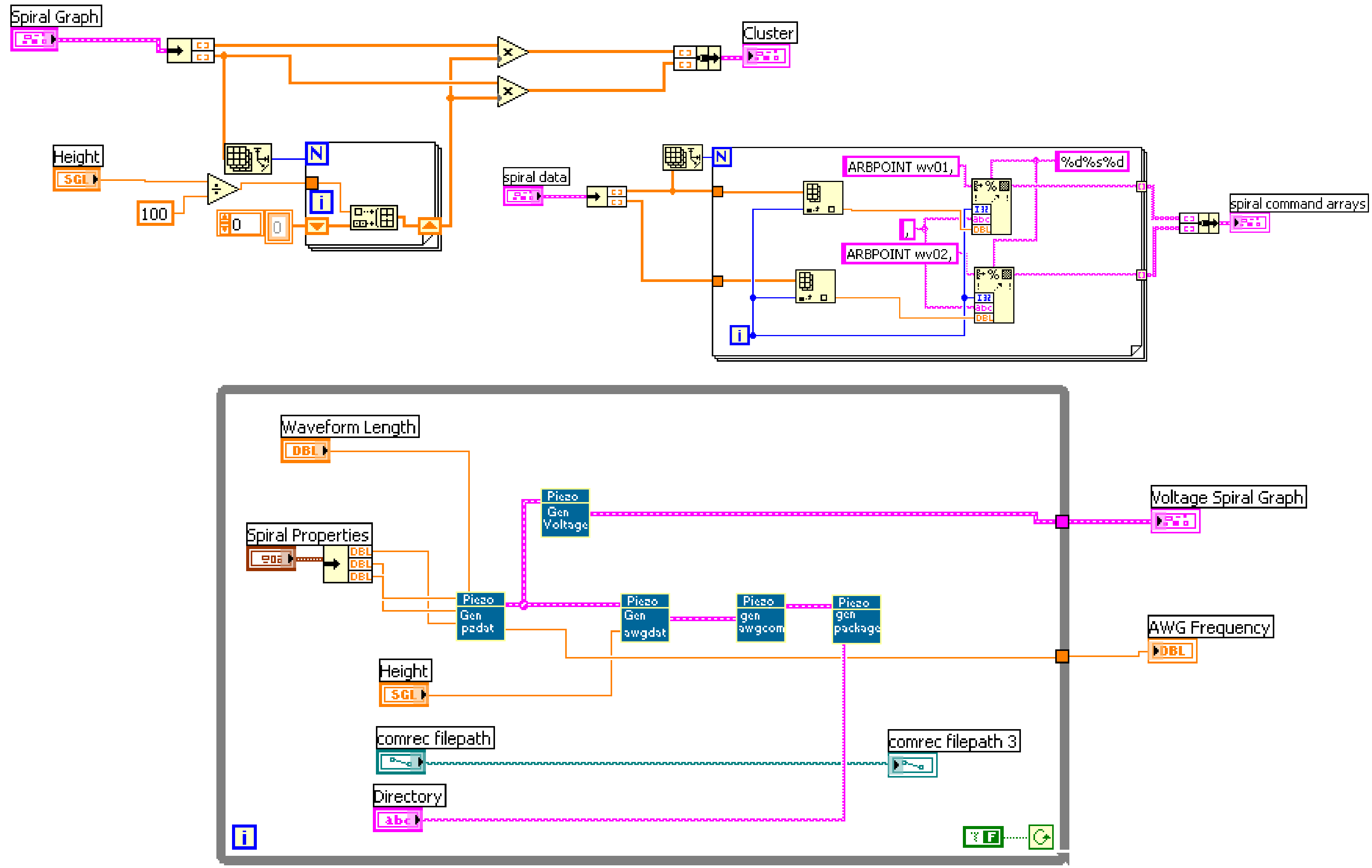
Labview implementation of the spiral trajectory



Labview processing of the spiral trajectory for delivery to the Arbitrary Waveform Generator (AWG)



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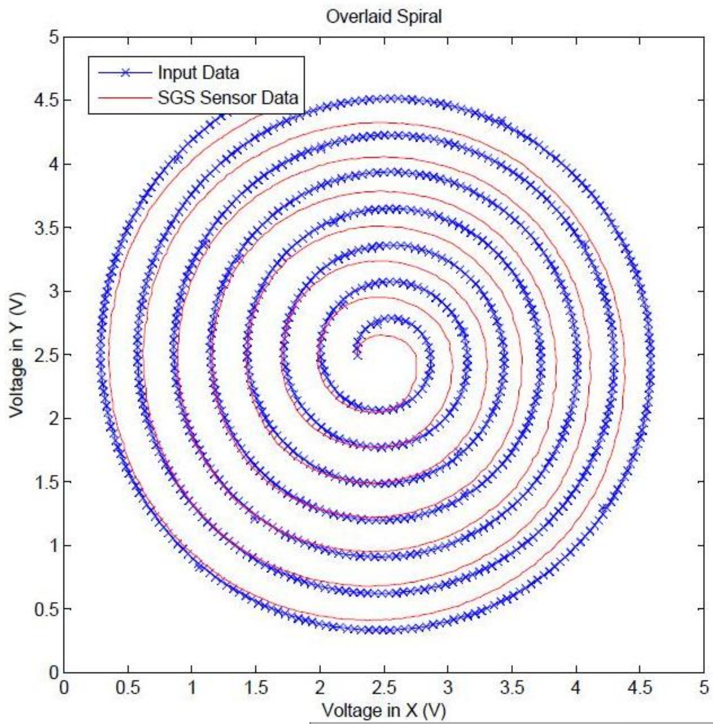
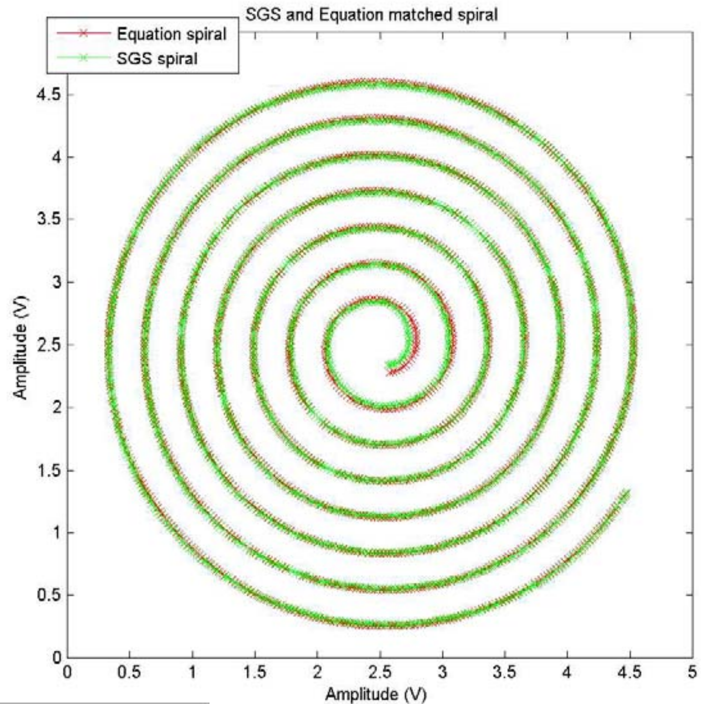
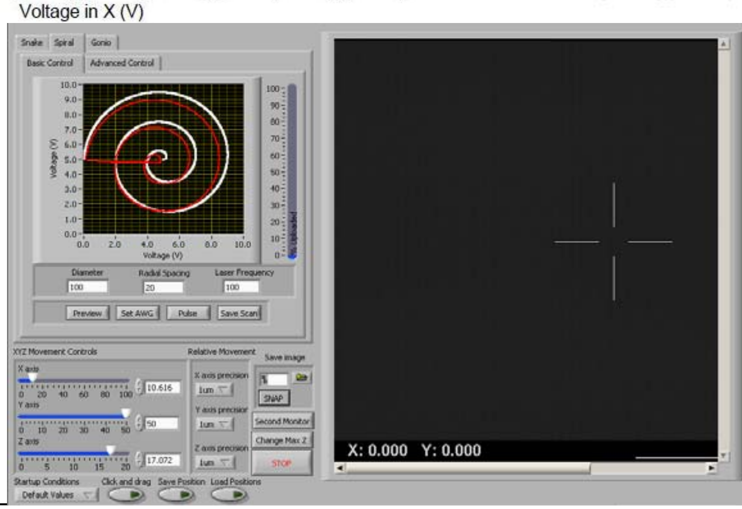
Curing mismatches between the theoretical and actual trajectories







Video Captures of Implemented Spiral Scanning Trajectories

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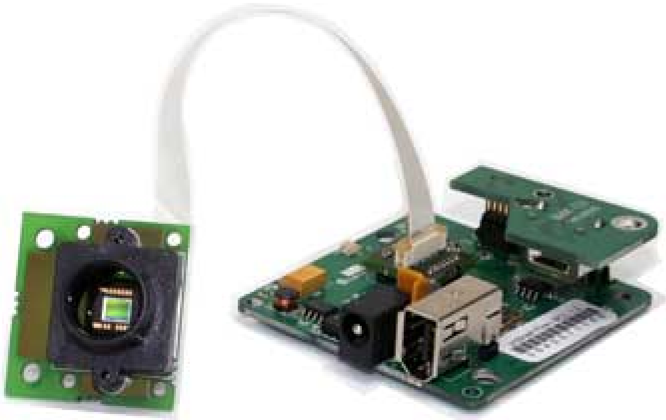
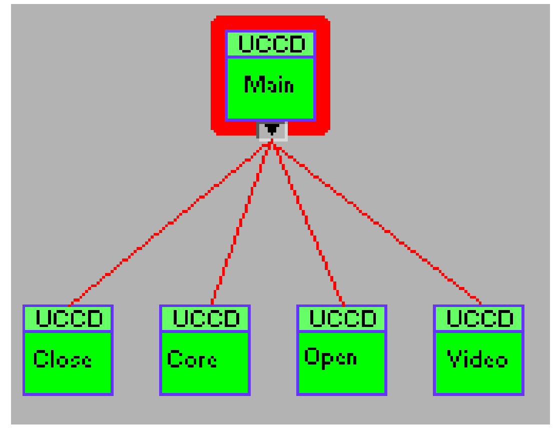
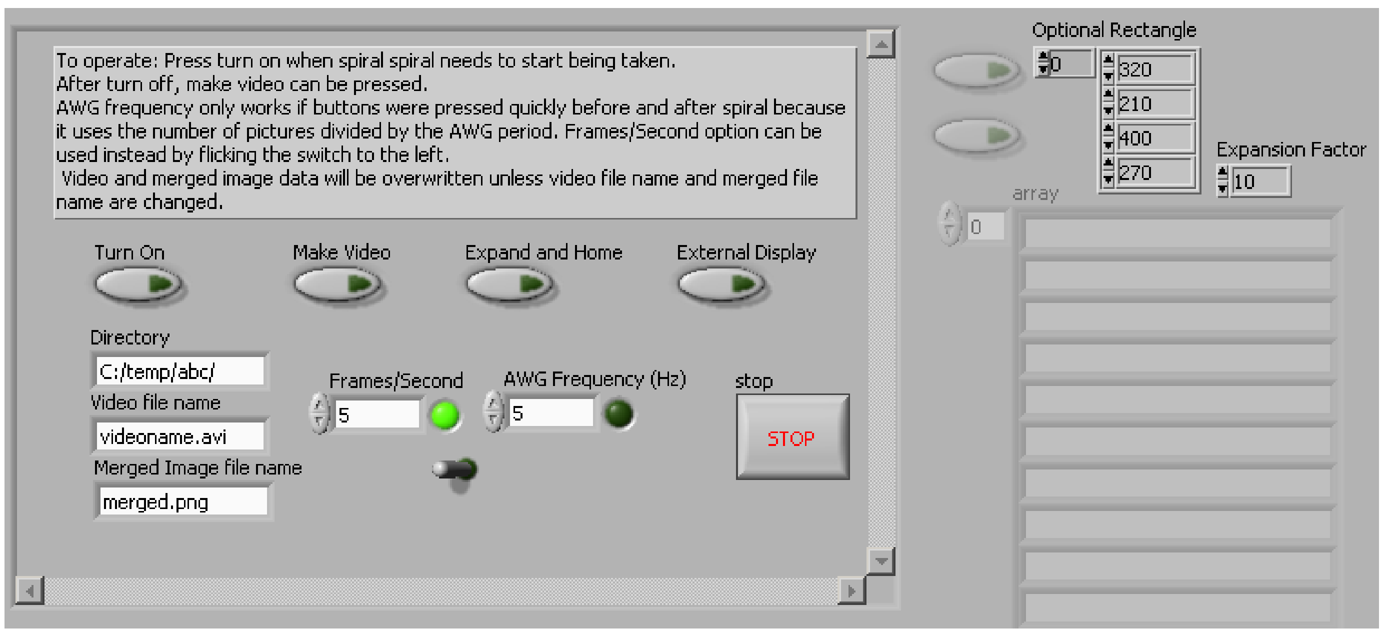
CCD Validation



The Unibrain Digital Board CCD Camera





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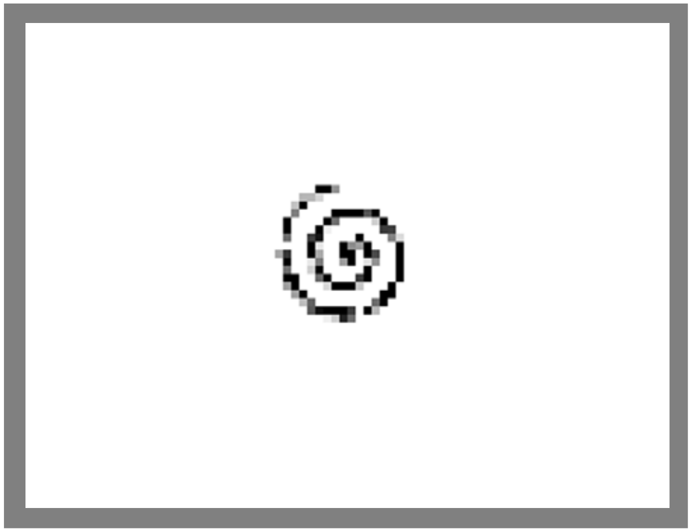
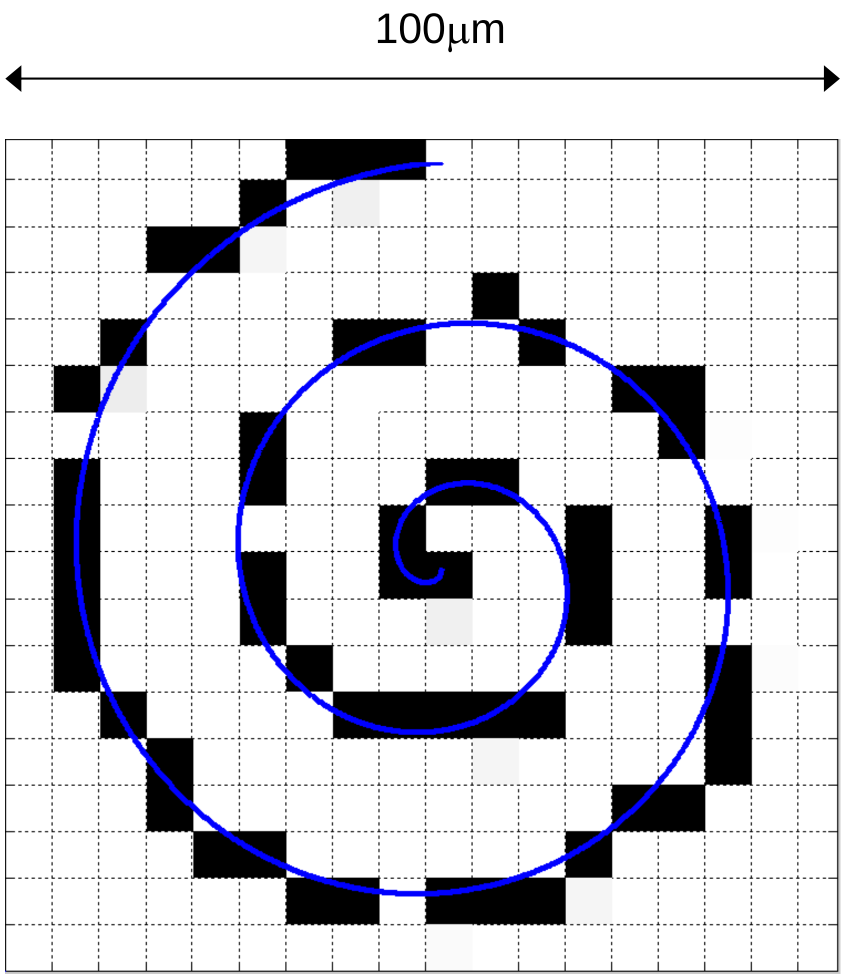
A spiral drawn into a CCD image with real SEREEL2 laser pulses



Integrated greyscale image from the CCD camera



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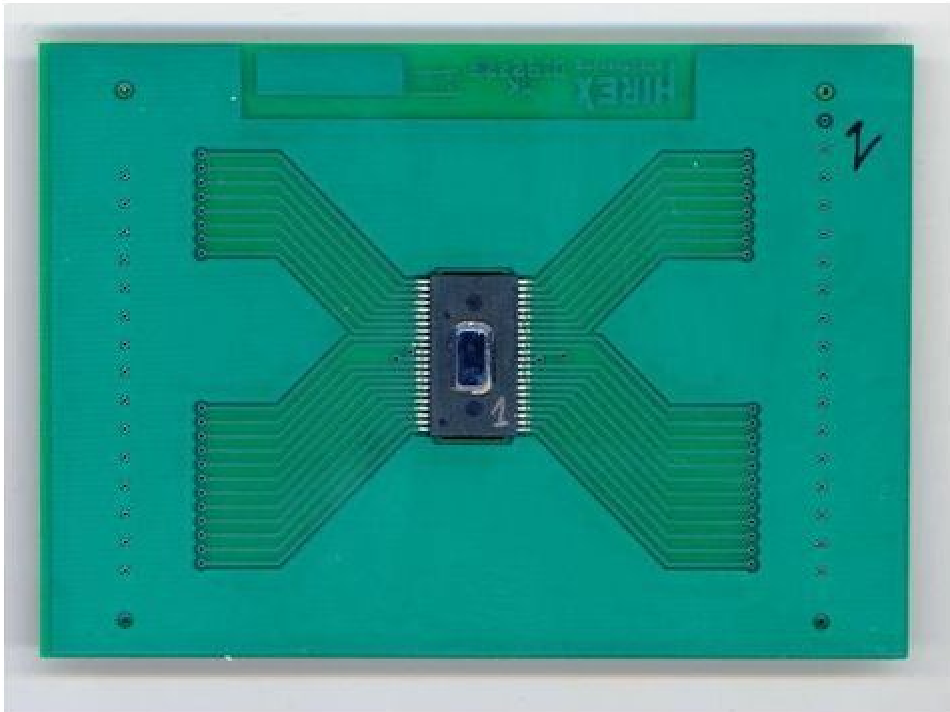
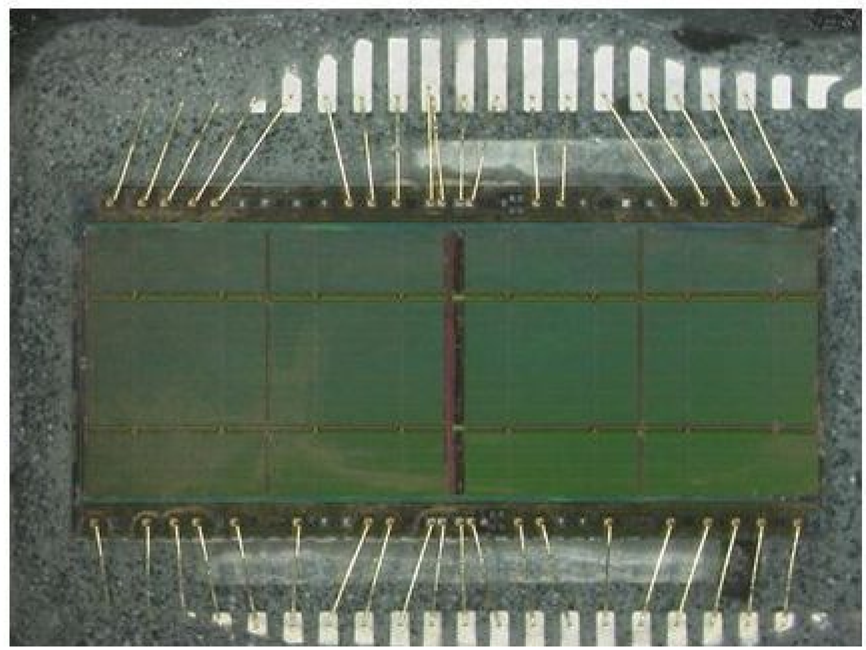
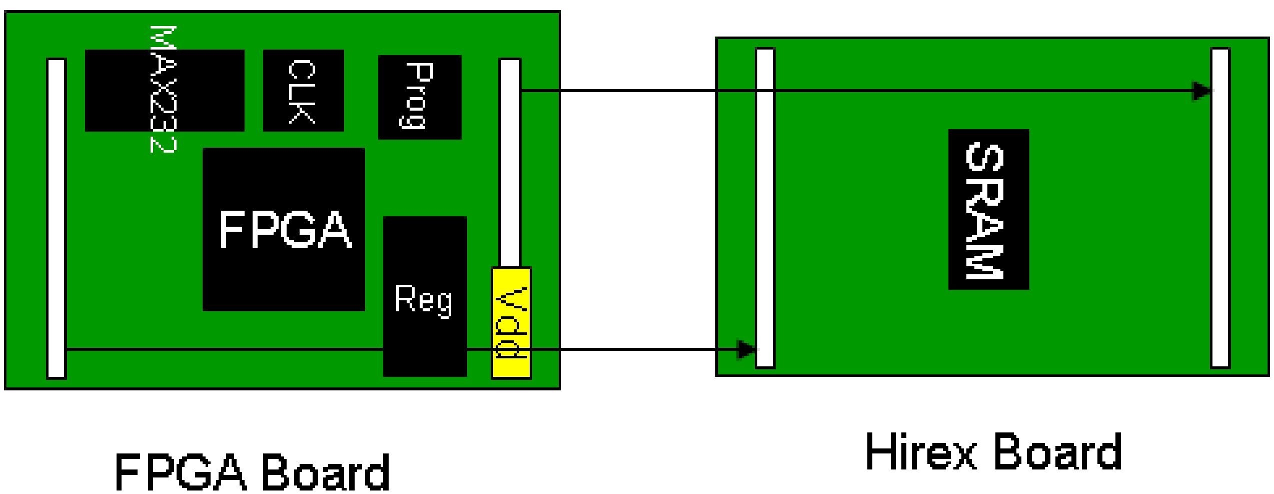
Backside polished Alliance AS7C34096A SRAM Sample (prepared by Hirex) plus a front side view





STREAM-lite – conceptual configuration

- A lighter version of the MBDA generalised memory reading system STREAM was required due to loading limitations for the piezo stage
- Additionally, we required additional STREAM functionality
  - To read selectable sub-sections of the memory with curtailed read-cycles
  - To synchronise STREAM more precisely with the positioning system



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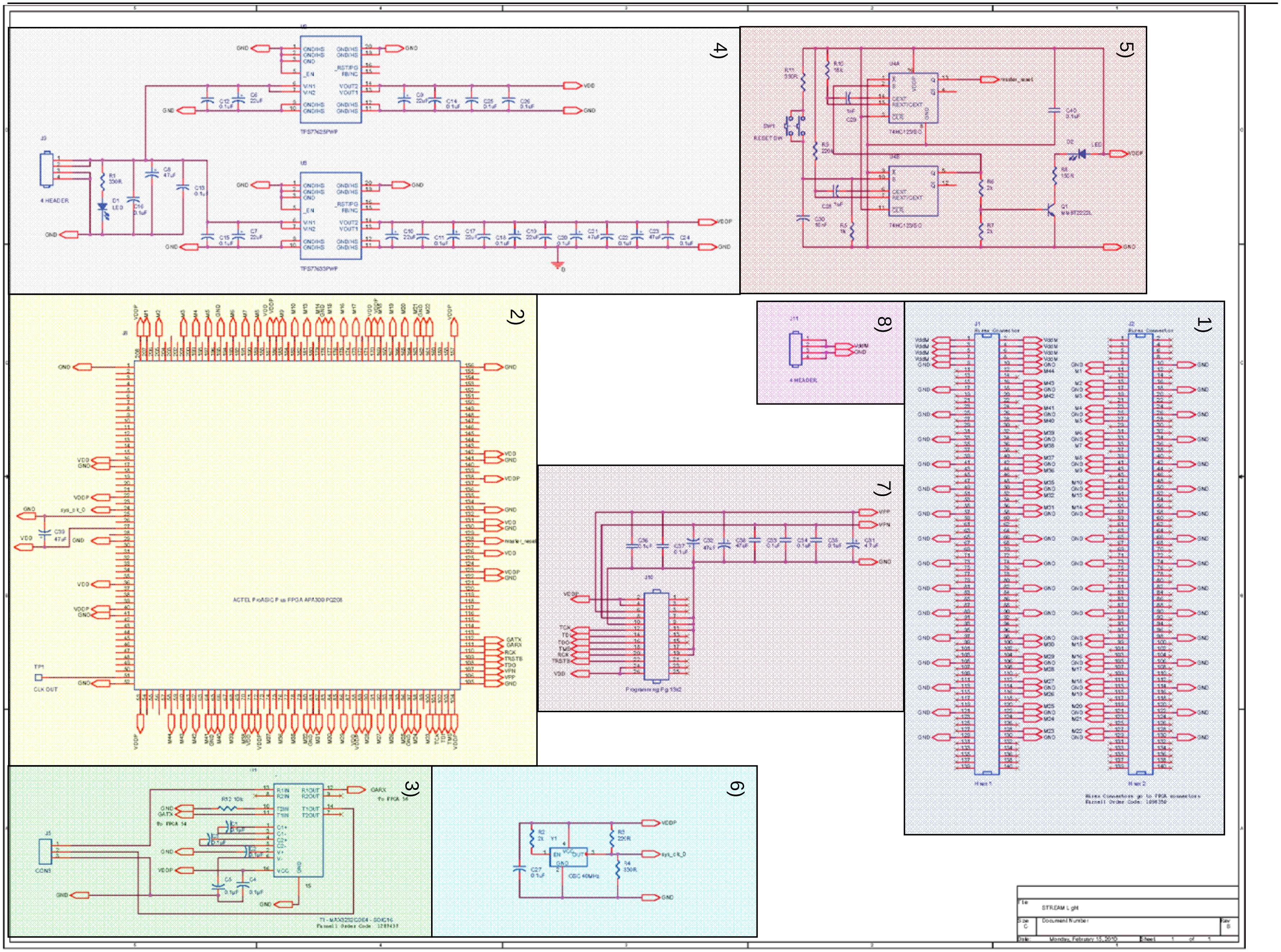
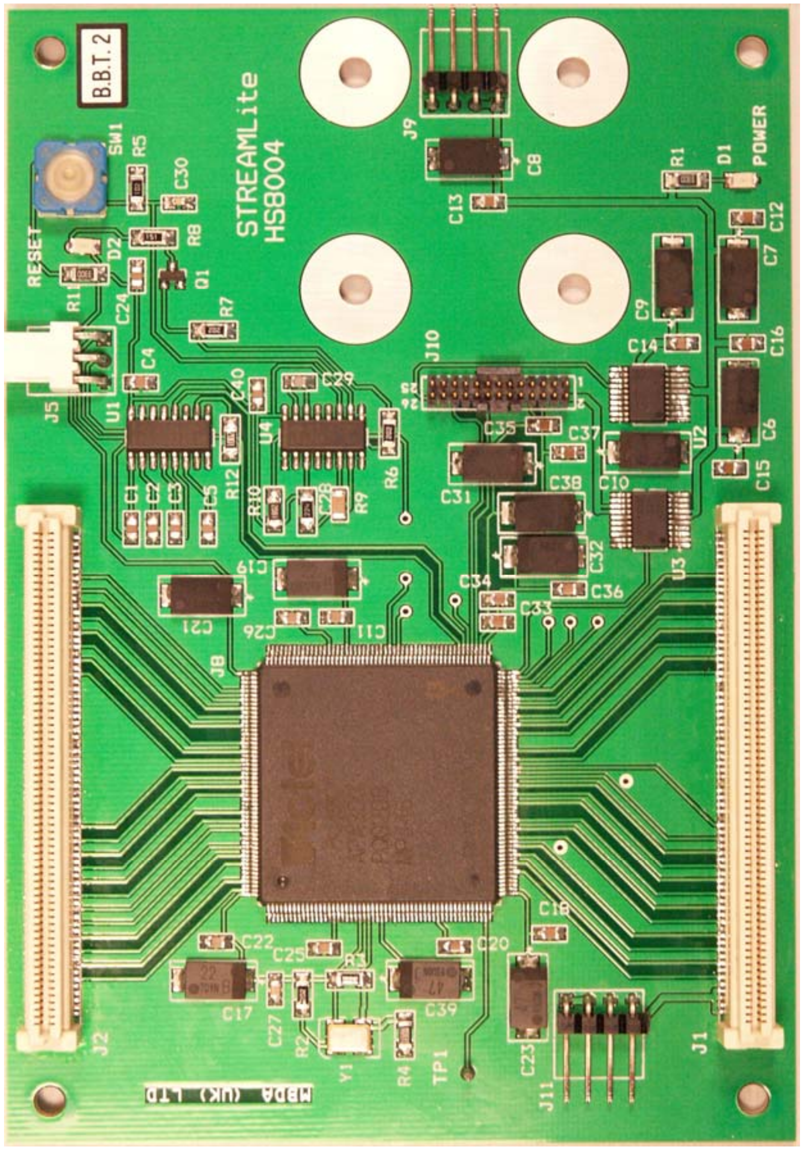
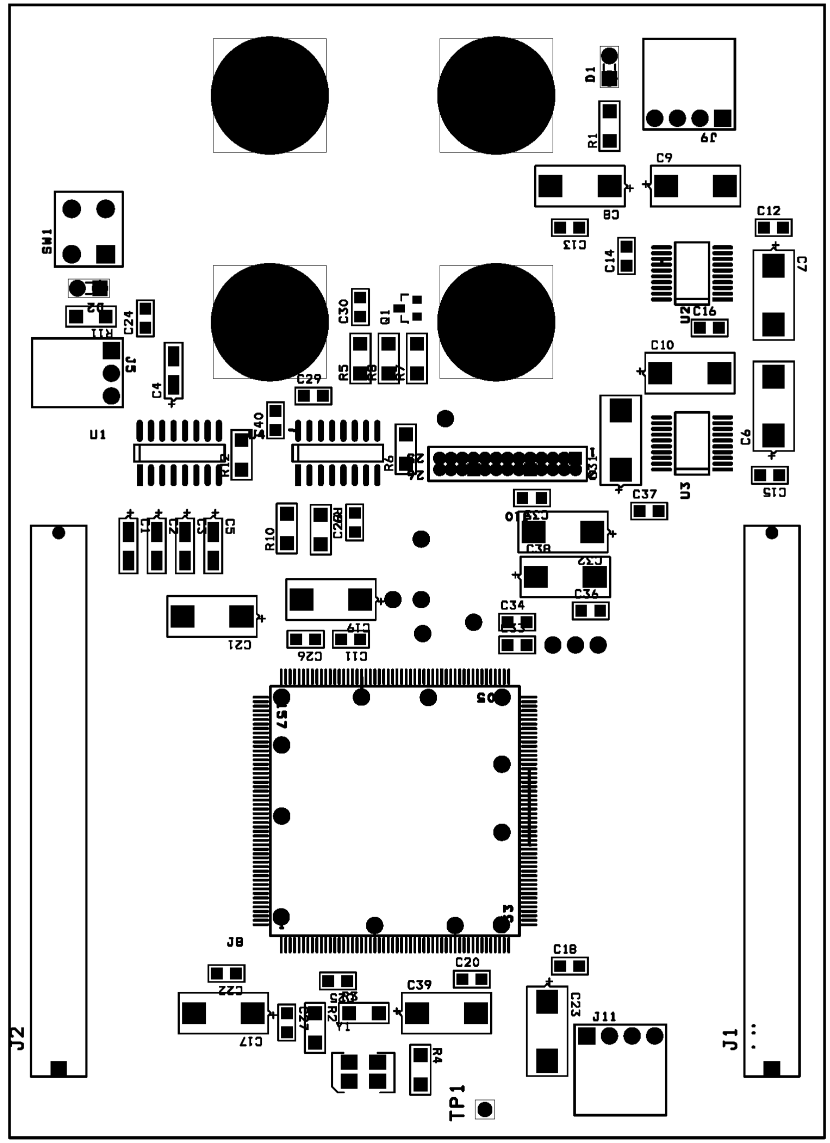
STREAM-lite circuit design



STREAM-Lite PCB and Layout





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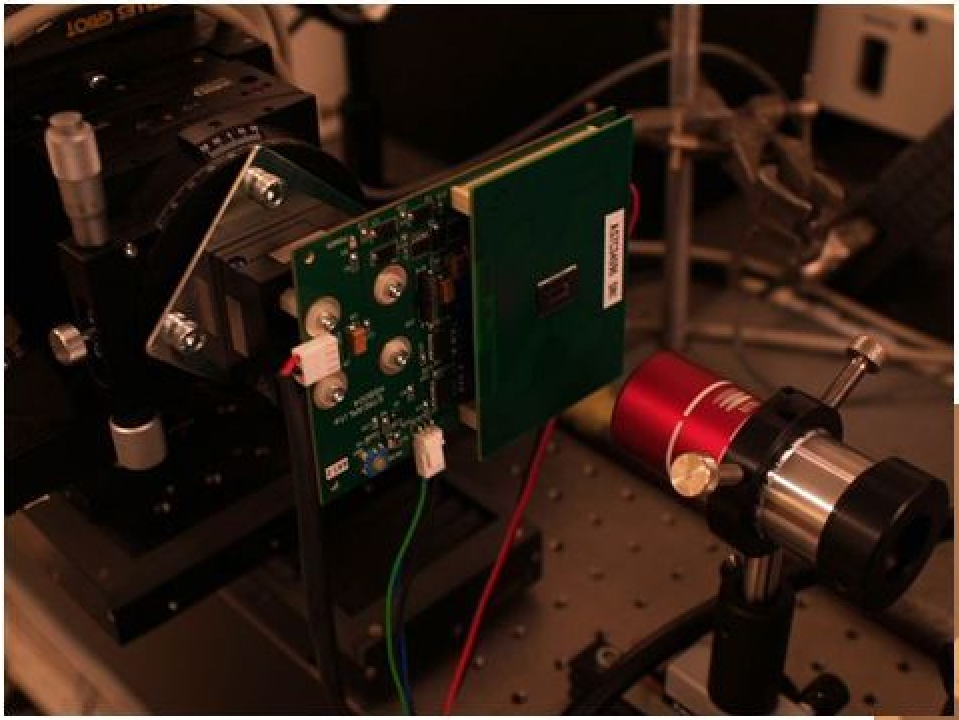
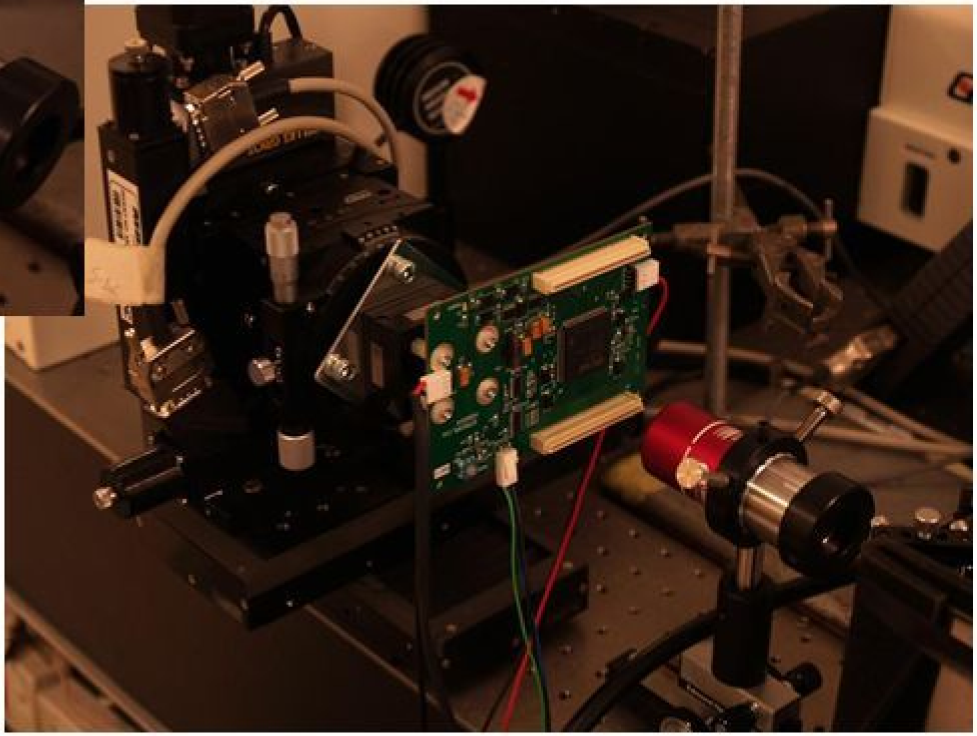
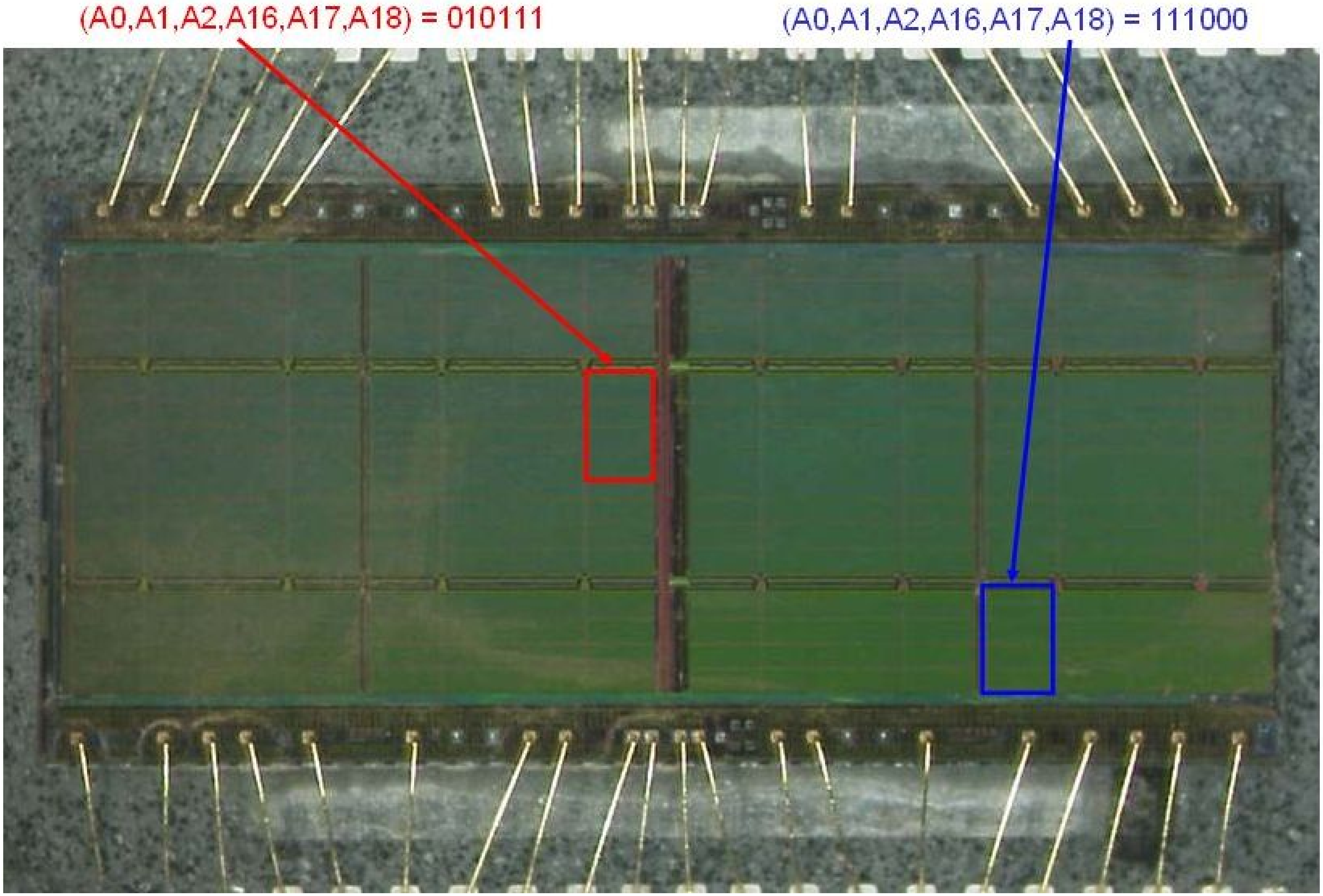
STREAM-lite implemented and mounted for laser testing with piezo-electric positioning





Addressing patches of memory to increase the read-cycle rate



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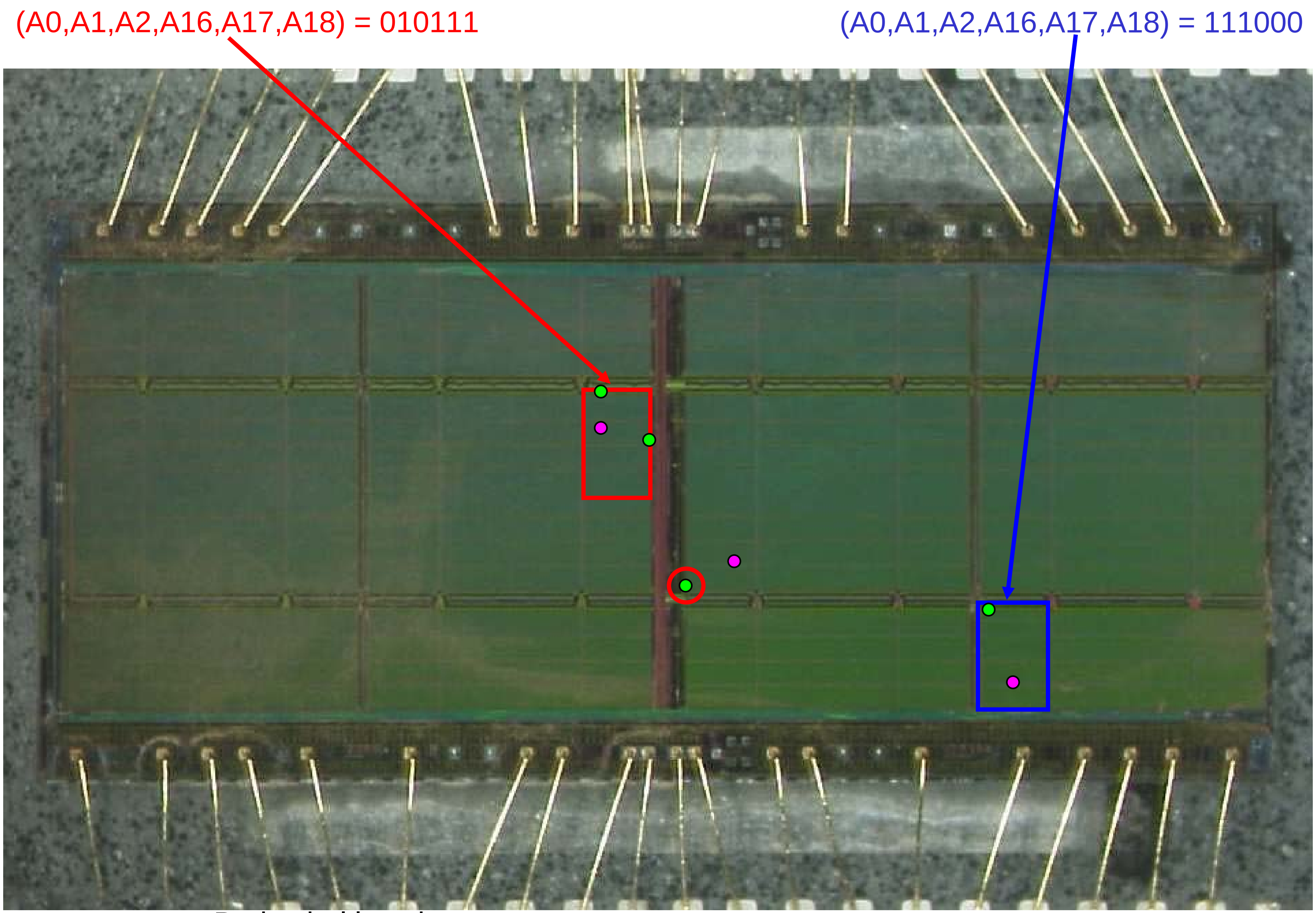
Addressing patches of memory to increase the read-cycle rate
Spiral array locations – those near memory array edges were best



Bad spiral location
Good spiral location

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Initial Error Threshold Mapping & Bit Address Descrambling

- A backside polished sample of the Alliance AS7C34096A SRAM was used to validate the new techniques in the context of an actual memory microchip
  - This is one of the devices currently being flown in ESA's Proba 2 spacecraft in the Technology Demonstrator Module
- The SEREEL2 system has an Optical Parametric Amplifier system, which can be used to generate laser pulses at ~1260nm for two-photon absorption (TPA) testing
- The Alliance sample had been polished down to only ~30μm substrate thickness, so it was possible to reach the sensitive regions with 800nm wavelength pulses, which is the fundamental frequency of the main SEREEL2 laser
- There is enhanced pulse-to-pulse energy stability at the fundamental wavelength, so we opted to use 800nm for this research.

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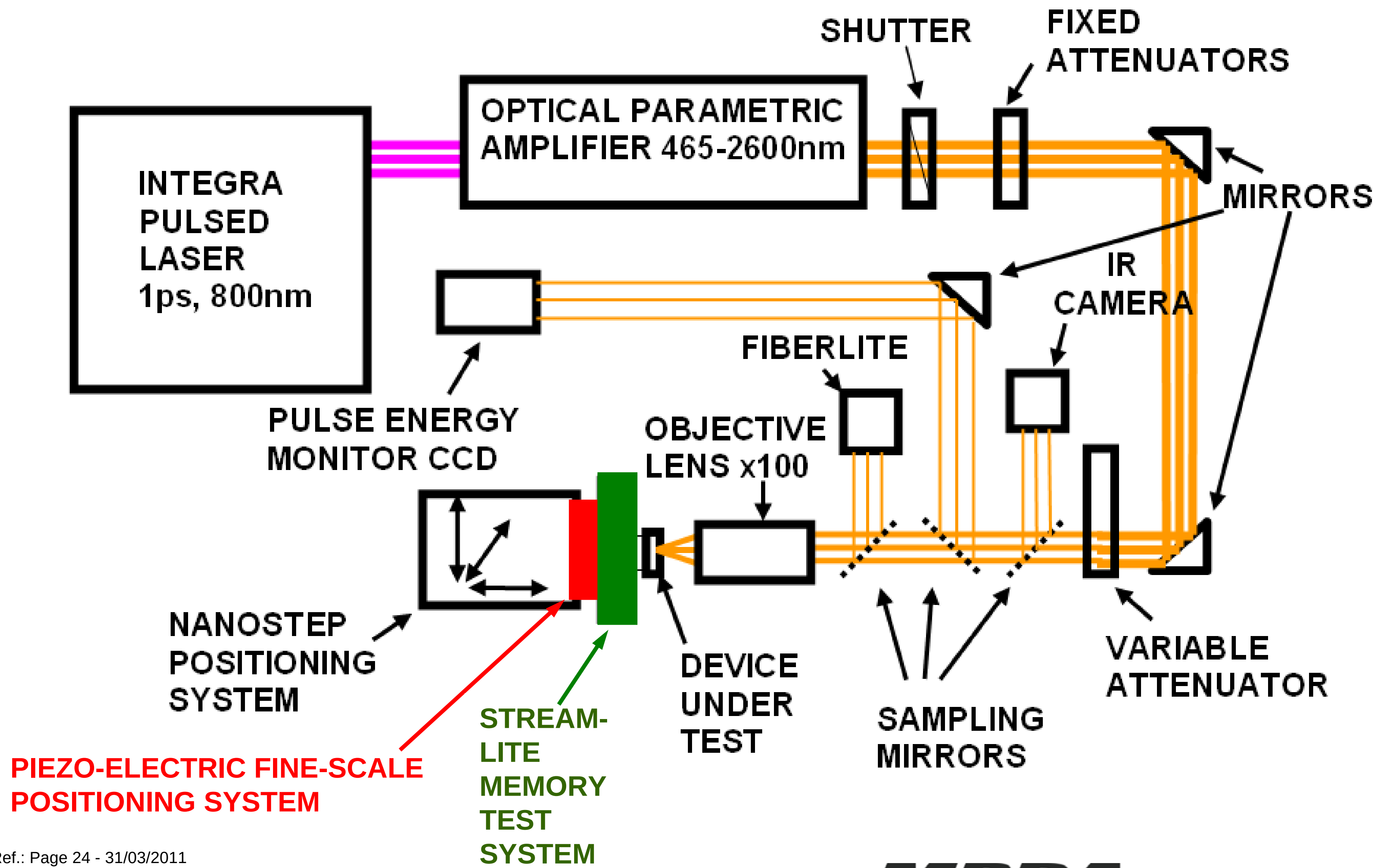
The SEREEL2 Laser SEE Test System with the Improved Sub-Systems



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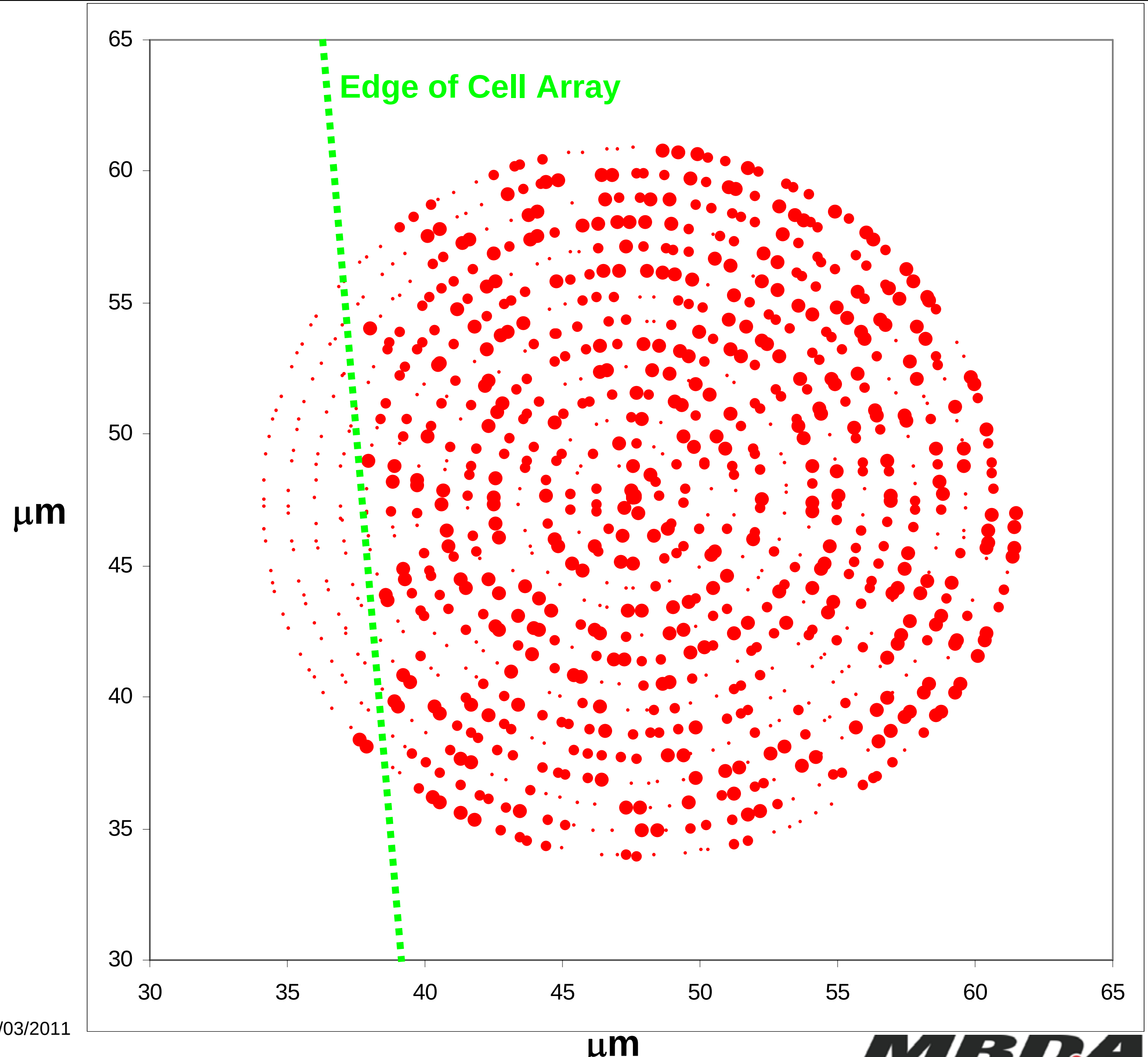
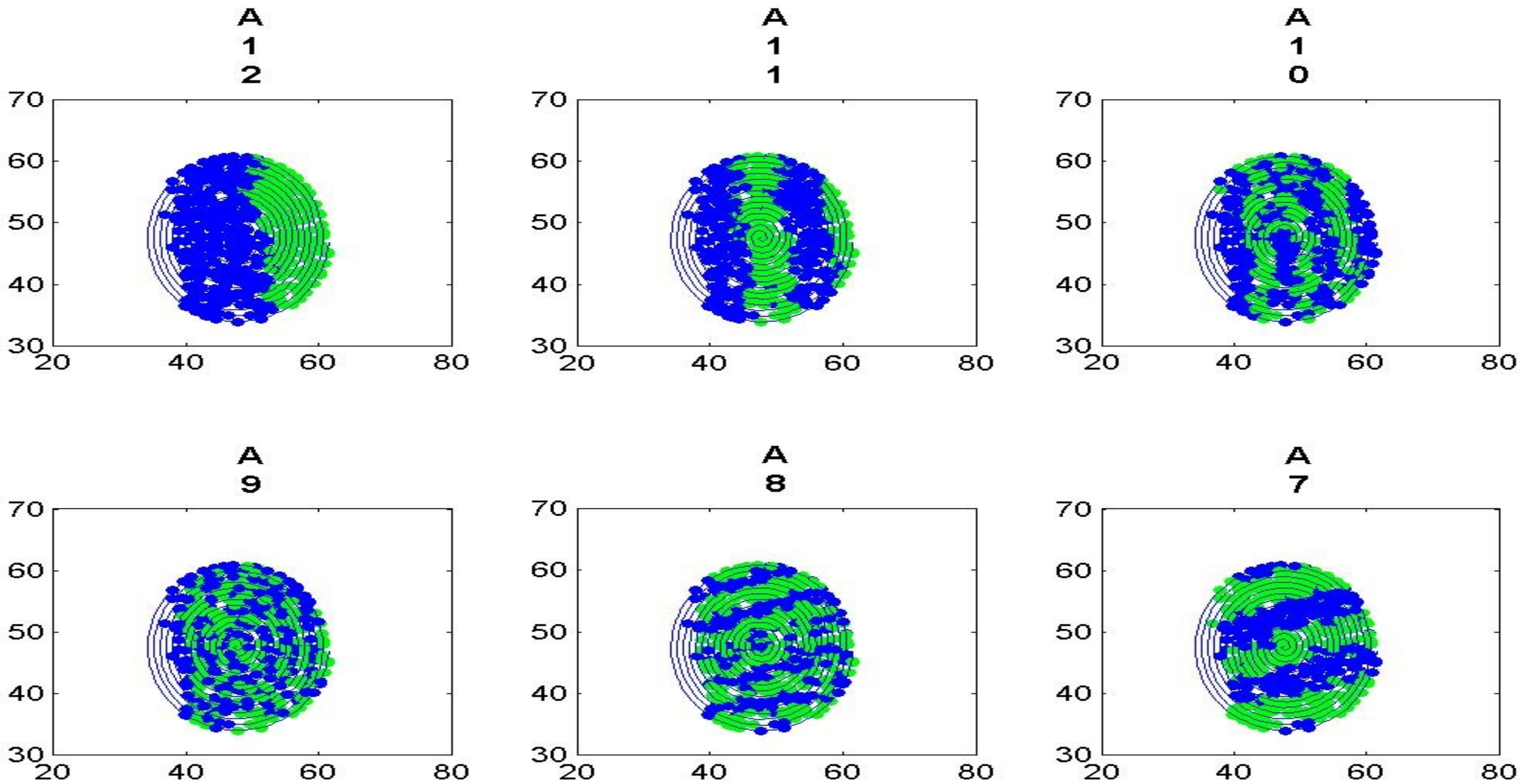
Upset threshold variation with pulse location – sensitivity is proportional to spot radius



Finest Scale Bit Address Descrambling



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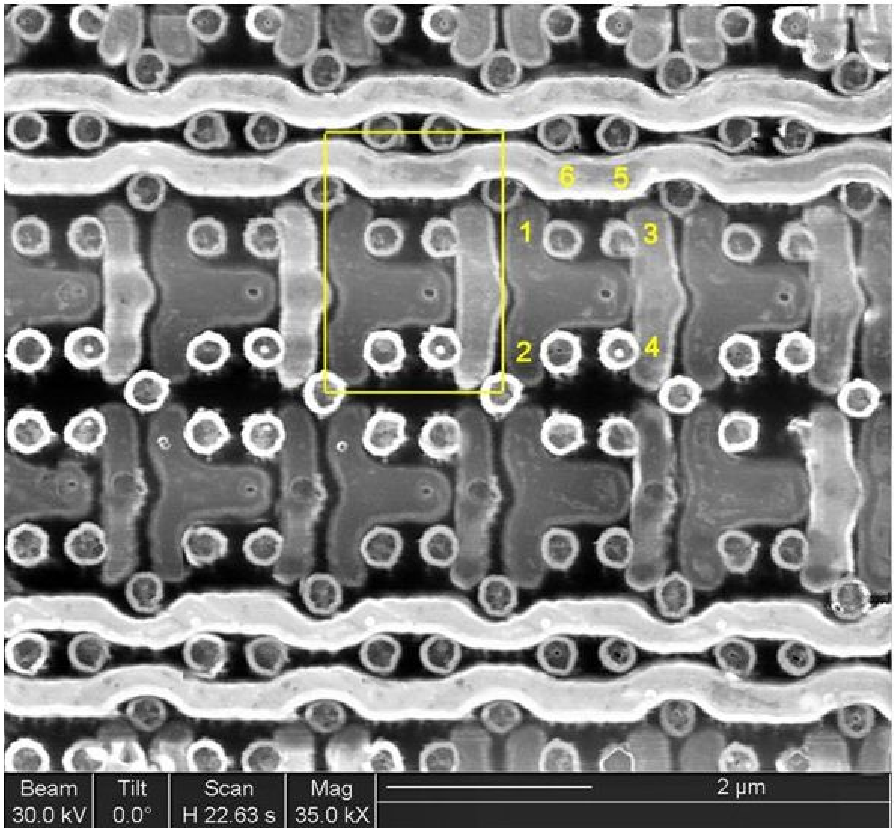
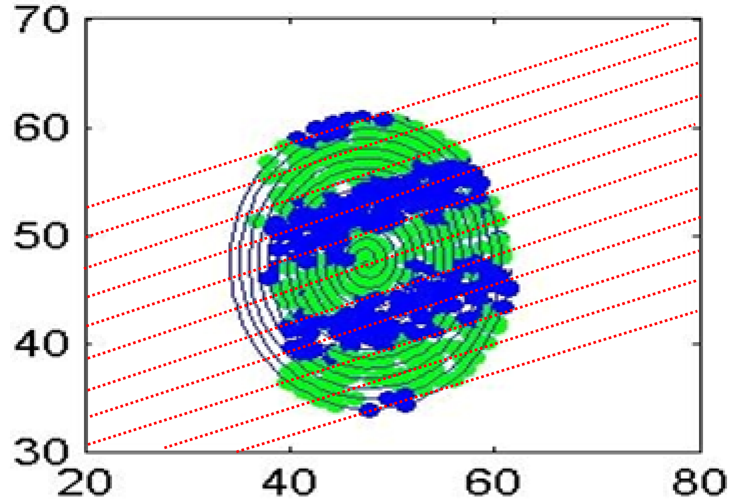
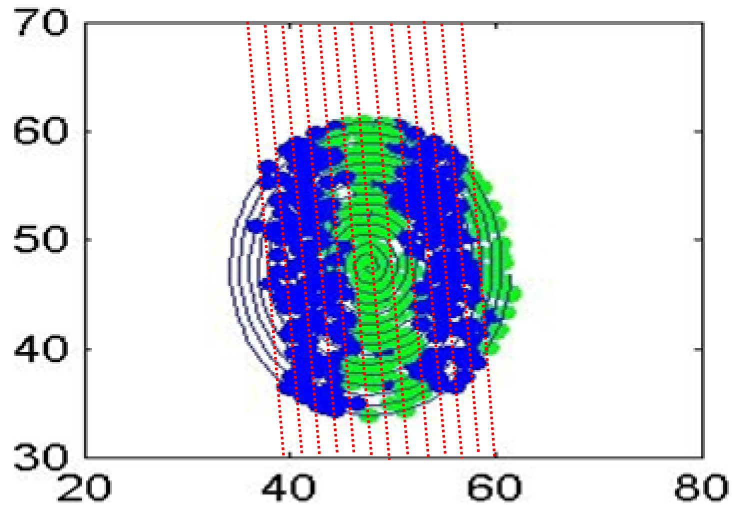
Alliance AS7C34096A SRAM Cells – 1.7µm x 2.52µm







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Conclusions

- Major advances and improvements in automated laser SEE sensitivity mapping achieved and demonstrated
  - Rapidity – 2D x-y array of 10,000 pulses delivered in 100 seconds
  - Repeatability – low acceleration and positioning precision of piezo devices
  - Flexibility – no constraints on the laser pulsing trajectory
- Validations
  - Drawing spirals of laser pulses onto CCD’s
  - Fully automated sensitivity mapping of a sub-block of Alliance SRAM cells
    - Built up in z-step layers of spiral laser pulse arrays
  - Fine scale memory descrambling for precise allocation of error sites
    - Confirmed against reverse engineering report for the parts