Montage imaging of large fields of view

Application Note
APEX XCT

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Abstract

Imaging of large fields of view at high resolution can be achieved by stitch-ing of multiple dataset volumes (montage imaging). We demonstrate Sig-ray's patent-pending Apex XCT's capabilities for imaging a large 100 mm x 80 mm PCB at variable resolutions from 8 μm to 1.5 μm for the complete intact volume.

Background

In microCT (also marketed as x-ray microscopy or XRM), there is a well-known tradeoff between field of view (FOV) and resolution that is limited by the detector pixel count. Typical detectors are 2000 x 2000 pixel formats, meaning a 0.5 μm voxel results in only a FOV of 1 mm x 1 mm (2000 pixels x 0.5 μm = 1 mm). Often, applications that require larger FOVs such as reverse engineering of large electronic packages or pouch cell batteries in materials science must accept coarser resolution tomographies.

Novel Approach: Sigray Apex XCT

Apex XCT™ is a breakthrough system that overcomes the FOV and resolution tradeoff. The system features a patent-pending acquisition approach that enables rapid (e.g. 10-30 minute) scans of multiple volumes at resolutions reaching down to 0.5 μm. The volumes can be then automatically stitched seamlessly together using Sigray's MegaView™ imaging package to provide a complete 3D dataset of a large FOV at highest resolution.

Unlike traditional microCTs and XRMs, Apex XCT achieves 0.5 μm even on large diameter samples such as PCBs and 300mm wafers. Such samples on other microCTs/XRMs would be impossible to image at reasonable throughputs, even at coarser resolution of several micrometers. Instead, destructive trimming of the sample is often required to image at submicron resolution.

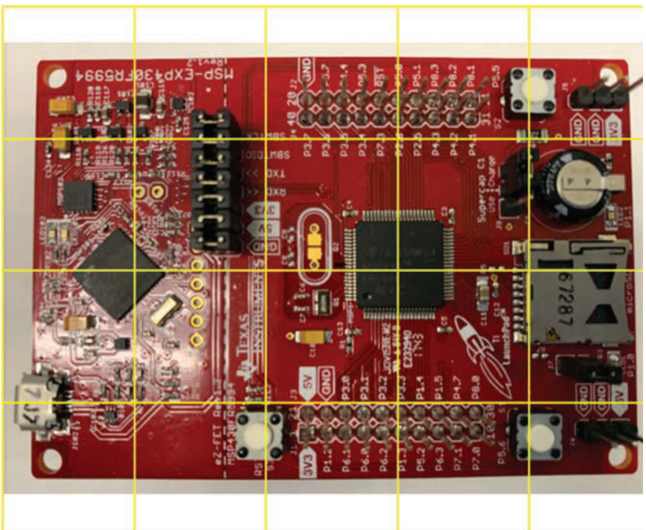

Figure 1: Large field of view montage tomography comprised 20 volume FOVs (4 x 5, outlined in yellow). Acquisition time for each sub-volume was set for 36 mins, with a total image acquisition time for the FOV encompassing the entire PCB at 12 hours.

Methods

In this applications note, we demonstrate how the large field of view (LFOV) and high resolution capabilities enabled by Apex's MegaView montage imaging package benefits the field of reverse engineering (also called construction analysis), which is rapidly growing in importance because of its use in detecting counterfeits, hardware trojans, and intellectual property infringement.

Sample: Sigray received a commercially available demonstration/evaluation board from Texas Instruments Model MSP-EXP430FR5994 Launchpad Development Kit. It is a PCB with dimensions of 100 mm x 80 mm.

Acquisition Parameters: The customer requested the following scans: a LFOV encompassing the entire board, then higher resolution scans on the processor unit.

Acquisition parameters for each of the scans were:

Scan Type	Voxel (μm)	Time / Volum
Full PCB FOV	8.0	36 min (20 volumes)
Processor FOV	4.0	24 min
Defect-Level Zoom	1.5	24 min
Parameters of three types of scans performed on the PCB		

Results

Full PCB FOV: To obtain a view of the whole board, a montage scan of 20 volumes was collected using 8 μm voxels. The 20 volumes comprised 5 columns x 4 rows (Fig. 1), with each volume only taking 36 minutes to acquire. The volumes (which had a 20% overlap with adjacent volumes) were automatically and seamlessly stitched together using Sigray's MegaView montage image package. Fig. 2 is the raw montaged image collected by the Apex without special image processing.

Fig. 2 demonstrates the lack of beam hardening artifacts through Apex XCT's acquisition approach, even in regions densely populated with metallic structures. Beam hardening has been a major challenge for conventional approaches because it makes automated extraction of traces, vias, bumps and components highly challenging or impossible.

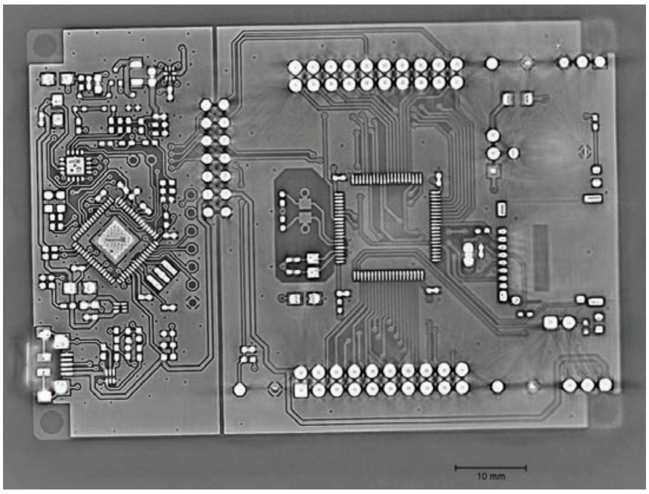

Figure 2: Sigray MegaViewTM - Montage imaging of larg FOV. Delayering plane of the FOV of the entire PCB (100 x 80mm) taken at 8 µm voxels. 20 volumes were collected and automatically stitched together.

Processor and Defect-Level FOVs: Without trimming the PCB, higher resolution scans were performed to demonstrate Apex XCT's power to image large intact samples at higher resolutions. A FOV of the processor volume (11.8 x 9.2 mm) was imaged at 4 µm voxels (Fig. 3), and defects (voids) in the interconnects surrounding the processor were imaged at 1.5 µm voxel (Fig. 4). The 1.5 µm voxel was performed by request, but Apex XCT easily achieves higher resolutions of 0.5 µm on large packages (see the XRM gallery on Sigray's website). Figure 3: Processor FOV. Cross-section of 3D volume taken at 4 µm voxels and 24 minutes.

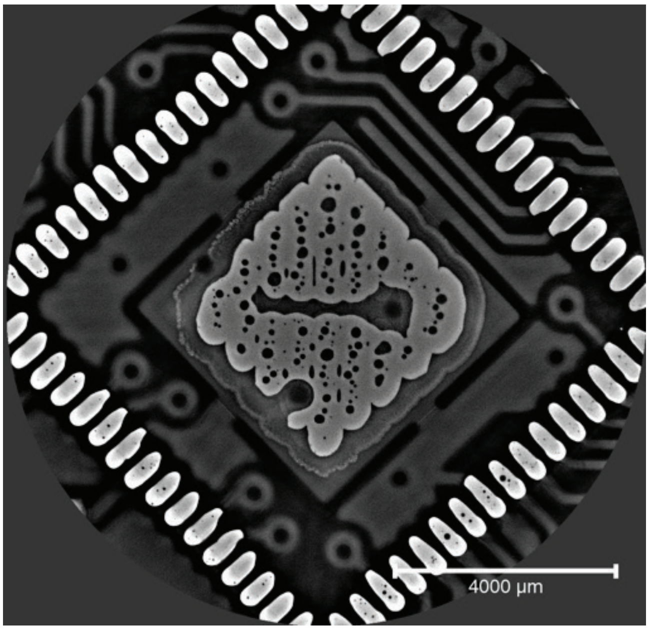

Figure 3: Processor FOV. Cross-section of 3D volume taken at 4 µm voxels and 24 minutes.

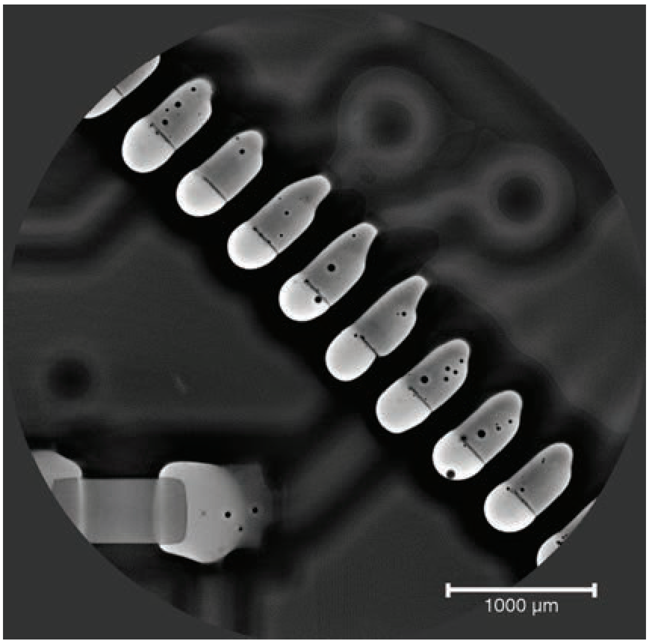

Figure 4: Defect-level FOV. Cross-section of 3D volume taken at 1.5 µm voxels and 24 minutes. Note that 0.5 µm can be easily achieved on this package, but the customer requested a 1.5 µm voxel

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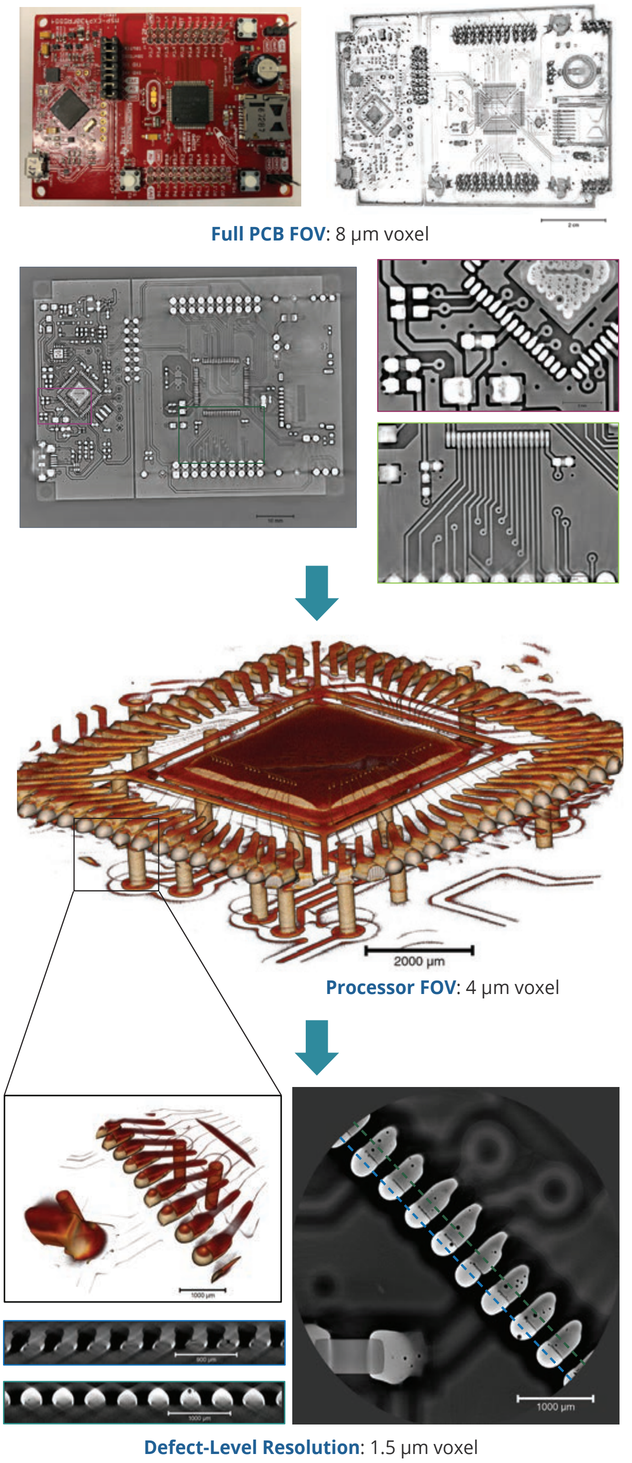

Figure 5: Workflow of acquisition, moving from a full PCB FOV montage to defect-level resolution on a region-of-interest.

Summary

Apex XCT is a novel 3D x-ray approach that breaks through the conventional constraints of resolution and FOV trade-offs. In this applications note, we applied the tool to imaging an intact PCB for reverse engineering purposes. Apex XCT acquired 20 volumes that were seamlessly stitched together using Sigray's MegaView package. Regions of interest (ROI) within the large FOV scan were identified for inspection at increasing resolution without requiring trimming of the sample (Fig. 5). The ability to image large diameter samples with large FOVs yet also high resolution is not only important for electronics, but also has major implications for biomedical applications (e.g., brain imaging) and materials science (e.g., pouch cell batteries).