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X-ray micro tomography of a nano-satellite

Abstract

X-ray computed tomography (CT) is being increasingly used in industry for dimensional quality control purposes. This method is applies to study the internal structure of the object and to find defects noninvasively [3, p. 495]. For this purpose, the high energy computed tomography scanner was developed at Tomsk Polytechnic University. The voltage of the system X-ray tube is 20–450 kV and the focal spot is 0.4 or 1 mm in size. The x-ray micro tomography of a nano-satellite (CubeSat) is described in this paper.

Key words: computed tomography, CT-scanner, x-rays, nano-satellite, non-destructive testing

Introduction

The design and implementation of pico and nano-satellites is a new stage in the development of space technology. Ultra-small Cubesat is one of the promising areas of engineering and technology in the aerospace industry. Satellites are being constantly advanced and as a result become a unique tool for scientific, educational and technological experiments in space.

Consequently, there is a need for non-destructive testing of nano-satellites. As a testing method was chosen X-ray microtomography due to its advantages. The paper focuses on the possibility of using X-ray microtomography to visualize internal defects nanosatellite.

Sample and method

The sample investigated in this research is a nano-satellite assembled by Astronomicon Laboratory (Moscow, Russian Federation). The nano-satellite is a cube with sides of 100 x 100 x 100 mm made of aluminum alloy. The module weight is 1 kg, the payload weight is 10–70 % of its the total weight, and resistance to overloads is up to 6 g. the The Cubesat made of different materials: the structure (chassis, cover plate and base plate) and machined components (e.g. the feet, spacers and Mid-plane Standoffs) are made from aluminum; all captive and loose fasteners and the Remove-before-Flight Pin are made from stainless steel; the male/female threaded standoffs supplied for development and prototyping are made from plated brass; printed circuit boards (PCBs) are double- or multilayer designs using a composite material composed of woven fiberglass cloth with an epoxy resin material. The physical configuration is shown in fig. 1.

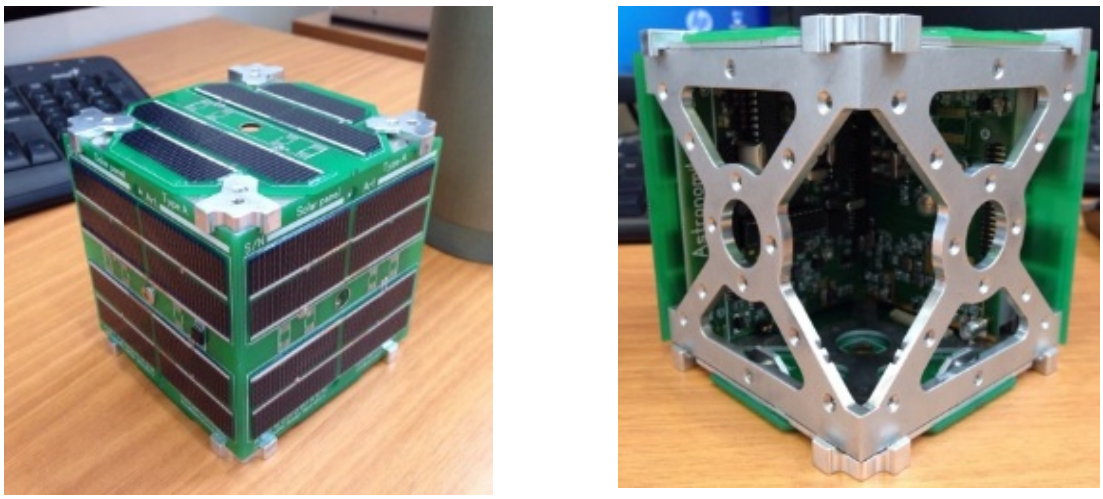

Fig. 1. Nano-satellite equipped with solar panels

Experimental set-up

The experiment has been carried out in TPU with the high energy CT scanner. This CT scanner uses cone beam geometry and is equipped with tungsten target X-ray tube and TFT detector with CsI scintillator [2, p. 243]. The parameters of the object scanning as follows: X-ray tube voltage is 300 kV, source current is 2.15 mA, data collection takes 45 minutes, and the resolution of the system is 100 µm. To reduce artifacts, a 0.5 mm copper filter was used. In total, 900 shadow projections were acquired to achieve voxel size of 200 µm [1, p. 379].

Results

According to the difference between the materials' density, the 3D micro tomography of the Cubesat is visualized using the special software for image processing and analyzing. Transfer functions make volume data visible by mapping data values to optical properties (fig. 2) [4].

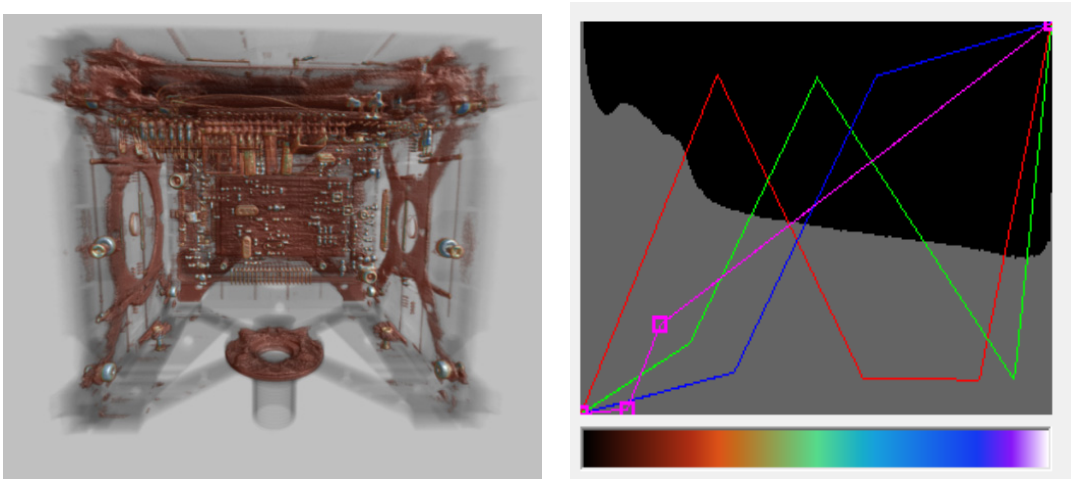

Fig. 2. X-ray micro tomography of a nano satellite:
a is a colored full volume; b is a color transfer function

The internal components of the satellite as cover plate, the feet, spacers, printed circuit boards are segmented from the full volume [5]. The components are illustrated in fig. 3.

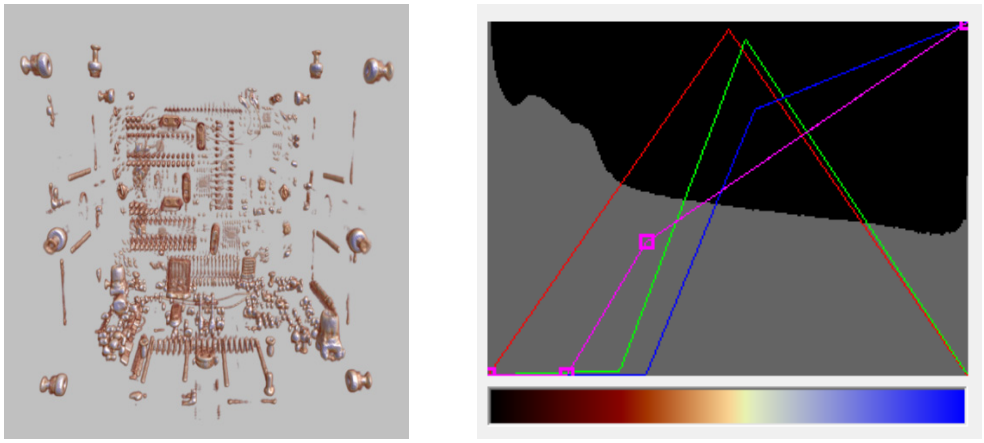

Fig. 3. X-ray micro tomography of the nano satellite:
a is a segmented inner structure, b is a color transfer function

Summary

Industrial computed tomography is under development. This paper demonstrates the importance of x-ray microtomography for non-destructive testing of the nano-satellite. The results of this work prove the reliability of the developed computed tomography scanner.

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