

## In This Issue

- Welcome
- Metrology of Medical Implant
- 3D printed plastic logo
- International client publications
- Upcoming events and News
- Acknowledgements
- Advertisement

## Recent interesting scans (clickable links)

### Metrology of a medical implant

<http://blogs.sun.ac.za/ctscanner/medical-implant/>

### 3D printed logo

<http://blogs.sun.ac.za/ctscanner/metrology-of-a-3d-printed-logo/>

### Previous newsletters with many more examples

<http://blogs.sun.ac.za/ctscanner/introduction/>

### 3D printing examples and services

<http://blogs.sun.ac.za/idea2product>

## Dimensional Metrology of a medical implant

Custom medical implants can be made to suit an individual patient using additive manufacturing (3D printing) technology. However, these parts need stringent quality controls, which is provided by 3D X-ray inspection. Besides looking for potential defects, dimensional accuracy can be tested – much like a Coordinate Measurement Machine (CMM) – just faster and with a much higher density of surface points. The part was built by the Centre for Rapid Prototyping and Manufacturing at the Central University of Technology, South Africa.

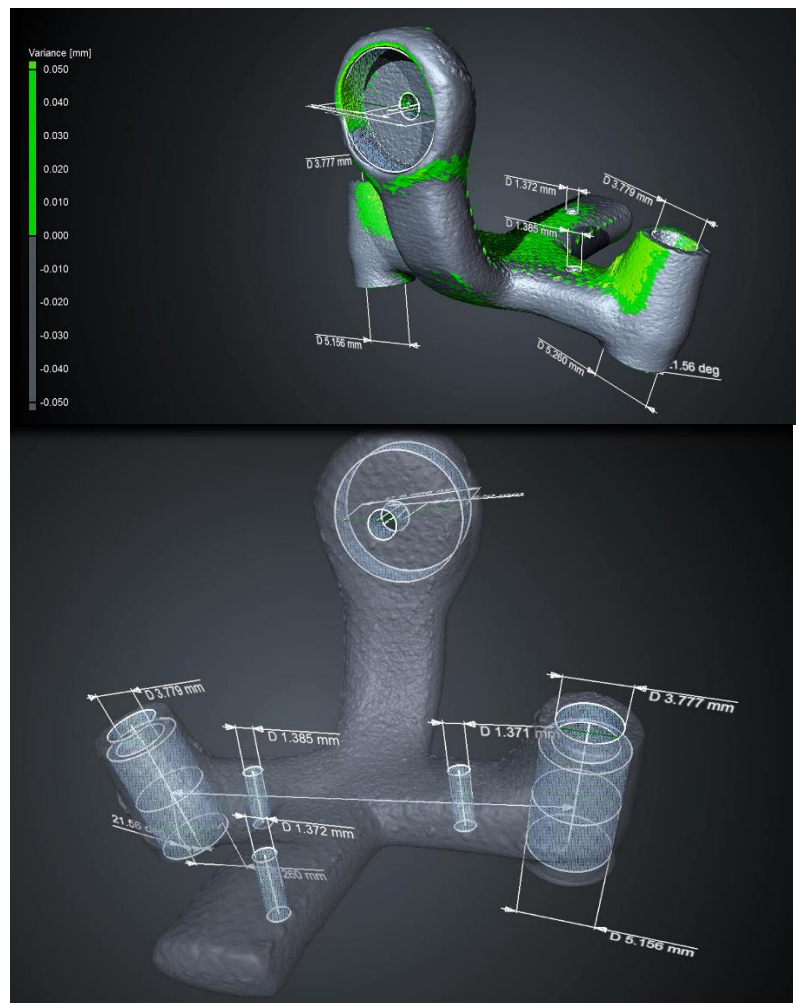
More images and video here:

<http://blogs.sun.ac.za/ctscanner/medical-implant/>

## Welcome

Welcome to our May newsletter. As always we want to share what we can do for you. As 20 May 2015 is World Metrology Day, this newsletter is focused on **metrology**.

X-ray microCT scanning provides the highest quality full 3D data available for dimensional measurement and validation (metrology) of your manufactured components. Our examples this month are a titanium medical implant and a plastic 3D printed promotional university logo.



**Figure 2: Additive manufactured titanium medical implant, click here for a great video on youtube:**

<https://www.youtube.com/watch?v=L7XONzvts38>

# Metrology of 3D printed logo

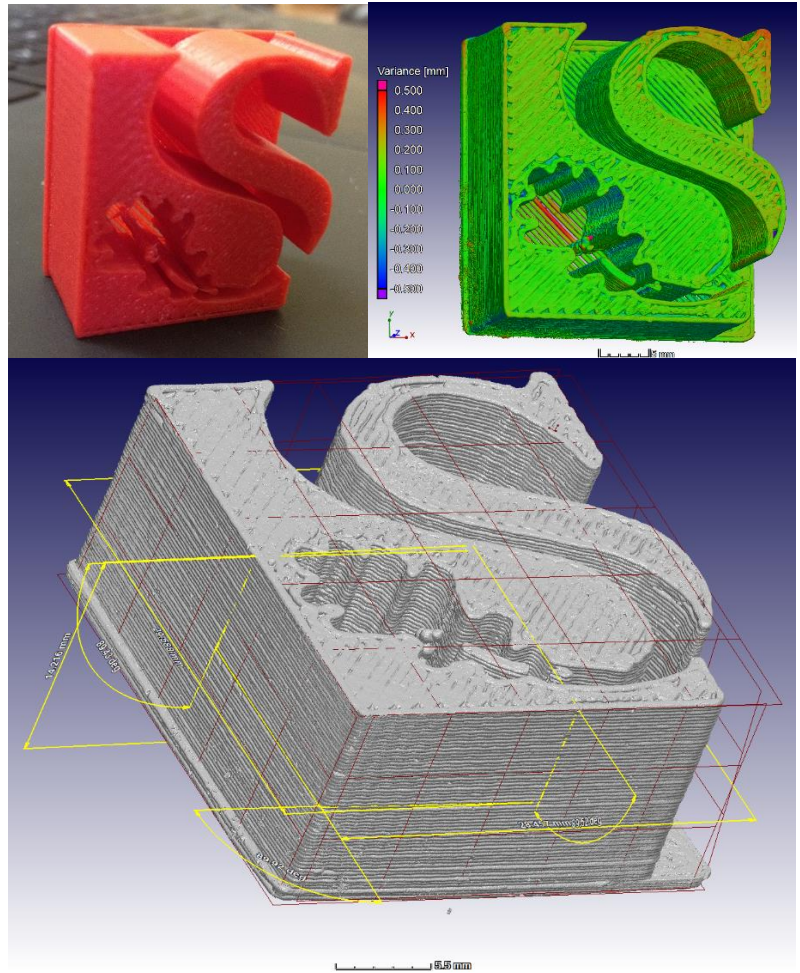
A 3D printed Stellenbosch University logo was designed and manufactured at the Stellenbosch Idea2Product lab, a division of the CT Scanner Facility which is located at the university's Launchlab: <http://blogs.sun.ac.za/idea2product>

This logo which is roughly 30 x 30 x 14 mm is intended to be used for marketing purposes, but also provides a nice example for dimensional measurement using the metrology toolbox of VGStudioMax 2.2. Using sub-voxel accurate surface determinations and fitting functions, very accurate dimensional data can be provided.

A quick overview initially can be provided by a part-to-CAD comparison as shown in Figure 2 top-right. Then, using best-fit planes and dimensional analysis, distances and angles can be measured much like a coordinate measurement machine. The CAD file (STL format) of the surface can be generated for use on other engineering software as well.

A high resolution scan plus basic part-to-CAD comparison and dimensional analysis using these software tools totals 3 hours per sample. For large batches, faster scan times can be used at reduced quality, bringing the time per sample down to 1 hr for >10 samples. Costs are R1300 per hour for commercial clients.

<http://blogs.sun.ac.za/ctscanner/metrology-of-a-3d-printed-logo/>



**Figure 2: Nondestructive analysis of a 3D printed Stellenbosch University Logo, printed in the Stellenbosch Idea 2 Product Lab using an UP! Printer: Actual part (top left), CT surface data vs CAD file 3D deviation (top right) and metrology toolbox measurements of distances and angles (bottom).**

# International clients

Our international clients have started publishing some of their results from our facility. Prof Irfan from Qassim University in Saudi Arabia did some interesting work on 3D porosity analysis of light metal castings. Below is a link to one paper and the other requires login, or mail us for a copy.

<http://www.hanser-library.com/doi/abs/10.3139/120.110727>

<https://www.asnt.org/me>

MATERIALOGRAPHY | 1

## Frequency analysis of volumetric porosity in aluminum castings at high and low cooling rates

Fahad A. Al-Hakki and Muhammad A. Yasar, Al-Qadisiyah, Iraq

**ABSTRACT**  
Three-dimensional porosity analysis was conducted using computed tomography for AlSi10Mg castings. Statistical analysis was performed to compare the porosities of the castings at high and low cooling rates. It was observed that the cooling rates strongly affect the formation of pores for both small and large pores. The thickness of small pores measured 0.00003 mm to 0.0004 mm, but for large pores, the thickness of large pores measured 0.0004 mm to 0.0004 mm. It was observed that lower cooling rates give rise to larger pores, which are known to be detrimental to castings in potential fatigue initiation sites.

**Keywords:** Computed tomography, three-dimensional porosity, aluminum, casting

METATECHNICAL PAPER

## Effect of Cooling Rates on the 3D Porosity of Permanent Mold Castings Measured by Computed Tomography

by Fahad A. Al-Hakki<sup>1</sup> and Muhammad A. Yasar<sup>2</sup>

**ABSTRACT**  
The 3D porosity obtained at different cooling rates in permanent mold castings was investigated. First, an aluminum alloy (Si 0.6% silicon) was poured into permanent mold castings, and tensile samples that had solidified at different cooling rates were extracted from different areas of the molds. The porosity of these tensile samples was evaluated by computed tomography scanning, and the effect of the cooling rate on percentage volumetric porosity and tensile properties was investigated. The 3D volumetric porosity ranged between 0.004 and 0.023% in L-shaped samples with higher cooling rates, while it was between 0.012 and 0.066% in L-shaped samples with lower cooling rates. It was found that the cooling rate profoundly affected the volumetric porosity, and better mechanical properties were reported for higher cooling rates. This research is one of the first investigations into quantifying the 3D porosity of permanent mold aluminum alloy castings.

**KEYWORDS:** 3D porosity, permanent mold casting, mechanical properties, computed tomography scans, aluminum alloy

**Introduction**  
Because of their high specific strength and specific stiffness, aluminum permanent mold and the casting on going primarily at automotive and aerospace components and structures. High-volume production made using the casting process include engine blocks, gearbox housings, chassis frames, structural housing for digital cameras, and cell phone enclosures. In 2011, 98.4 million metric tons of metal castings were produced, with aluminum alone accounting for 13.1 million metric tons (Modern Casting, 2012). Compared to other casting processes, permanent mold casting provides great cost savings, especially when large production volumes are involved. It offers the advantage of fast changeover, fast tooling and rapid solidification under high pressures, which results in finer finishes and spacing and thus better mechanical properties. However, permanent mold castings have a higher risk of failure due to porosity and other manufacturing discontinuities created during the casting and solidification processes, as well as stress concentration effects from the complex geometry of the casting (Lopez et al., 2005). Porosity reduction has emerged as the largest technological challenge in the metal casting industry (Young, 2013). For example, permanent mold aluminum castings are widely used in auto parts and household appliances, and porous parts act as the single leading problem in these castings, greatly affecting their mechanical strength and lifetime. In fact, most measurements of porosity have been made in 2D (area porosity), and very little research into measuring the volumetric porosity in 3D and quantifying its effect on the mechanical properties has been reported (Lima et al., 2010). Previous research in this area can be briefly summarized as follows.

The first work reported the tensile properties of specimens machined from castings and their dependence on the percentage area porosity (Cheng et al., 2004). These tests showed that tensile strength can be higher than tensile strength than those machined from the castings because of the rapidly solidified surface "skin," which has little or no porosity on the secondary cast test here. Another group conducted tests on aluminum 319 (aluminum-silicon-copper) alloys (Dobson and Allison, 2001). The cast microstructure

**Figure 3: Recent publication screenshots from one of our international clients**

## News & events

Our locally hosted national X-ray tomography conference is planned for September, please register now and submit your abstracts:

- **2<sup>nd</sup> national microCT conference IMGRAD** (imaging with radiation): 10-11 September, first announcement: <http://blogs.sun.ac.za/ctscanner/imgrad2015/>

The first 10 abstracts submitted get free registration, so hurry.

**Abstract deadline 30 June**

### Contact Us

<http://www.sun.ac.za/ctscanner>

Staff scientist – Anton du Plessis, PhD

[anton2@sun.ac.za](mailto:anton2@sun.ac.za)

Analyst – Stephan le Roux, MSc

[lerouxsg@sun.ac.za](mailto:lerouxsg@sun.ac.za)

**021 808 9389**

### Physical address for sample deliveries:

CT Scanner Facility, Room 1046

PO Sauer building - Dept Forestry and Wood Science

Bosman Street, Stellenbosch

7602

## Acknowledgements

The CT scanner equipment acquisitions were made possible with grants from the National Research Foundation and Stellenbosch University. The Department of Science and Technology Internship program is also acknowledged for its support of this facility. We encourage and welcome any form of sponsorship or support in order to keep delivering the best quality. Stellenbosch University support of CAF allows special internal rates, subject to acknowledgement of our facilities in publications.

Researchers: provide us your equipment to manage as part of our facility, in exchange for zero cost of usage, free maintenance and upgrades. This is a win win situation, where we use it to maintain our facility and enhance our materials analysis capabilities.

**To subscribe or unsubscribe from this mailing list, please send an email with the subject line "subscribe" or "unsubscribe" to [anton2@sun.ac.za](mailto:anton2@sun.ac.za)**

**Please support our  
advertiser, Volume  
Graphics**

# HONEY, I SHRUNK THE CT DATA!



## MAXIMUM PRECISION, MINIMAL CT DATA SET SIZES

Measure on voxel data, point clouds, meshes, and CAD data with **VG Metrology**, Volume Graphics' new universal metrology solution. Our easy-to-use stand-alone application turns your computed tomography (CT) scanner into a comprehensive and precise metrology device.



**VG Metrology** gives you the most precise picture of all object surfaces you can get – and saves it in a new, very compact file format.

In contrast to tactile and optical methods, industrial CT scans all surfaces of an object, even if they are inside your part or difficult to capture. The metrology capabilities of Volume Graphics software are verified by the Physikalisch Technische Bundesanstalt (PTB), Germany's national metrology institute.

Working with a surface based on the original voxel data offers you both a subvoxel precision that is hard to match with mesh data and small, easy-to-handle files. Our new file format is efficient since it contains only the surface of the object. Its files are very precise and at the same time smaller than mesh files with standard precision.

You want to know more? Just contact us!



### VOLUME GRAPHICS GMBH

Wieblinger Weg 92a | 69123 Heidelberg, Germany  
Phone: +49 6221 73920-60 | Fax +49 6221 73920-88  
sales@volumegraphics.com | www.volumegraphics.com