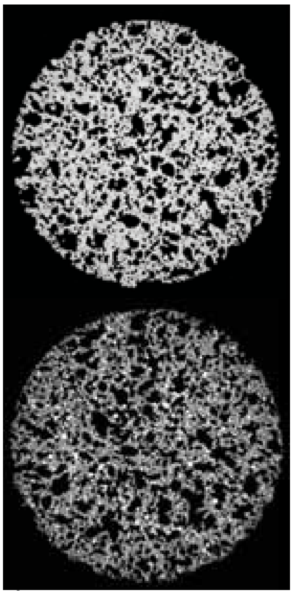
Nikon Metrology CT-scanner grades up titanium implant research at NRC

Industrial material researchers at the National Research Council Canada (NRC) investigate titanium foam plugs that have been implanted into rabbits. After six weeks, they operate a Nikon Metrology XT H industrial CT-scanner to visualize bone ingrowth into the porous titanium foam implants. Fast reconstruction of volumetric images enables the researchers to accurately trace where and to what extent bone structure has penetrated into the porous implant. Micro CT-technology allows the researchers to study – in 3D, with increased speed, depth and precision – the behavior of the porous material, and is a major step forward for material development when compared to destructive and time-consuming 2D imaging technologies.

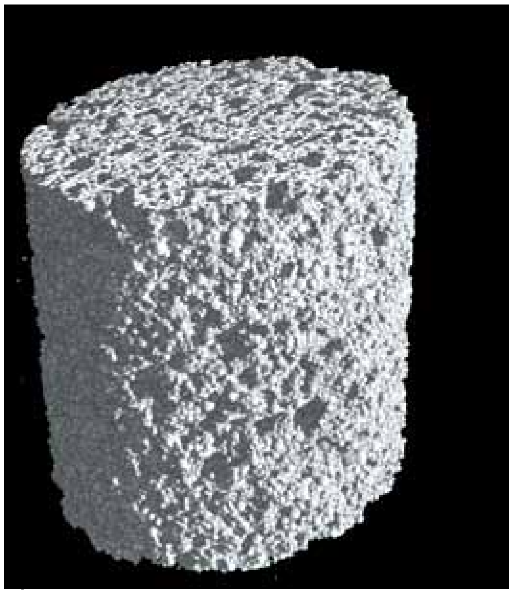
CT-empowered material research and in-vivo testing

In general, the development of implants is a 3-step process : developing innovative implant material, in-vitro biocompatibility and in-vivo animal testing for implant prototypes validation, and testing implants in human beings. NRC extensively uses the industrial Nikon Metrology CT-scanner both for implant-related material research and in-vivo testing purposes.

Titanium foam is a material that is particularly suited for implants because it combines biocompatibility, good surface roughness and high strength. Its ramified porous structure provides sufficient room for bone ingrowth. Industrial material researchers use the CT-scanner – equipped with 225kV x-ray micro-focus source and 2000x2000pixel flat panel – to closely monitor the processing steps of titanium foam. Reconstructed CT-volumes of the structure before and after the sintering step enable researchers to verify pore size distribution, the presence of defects, and evaluate the dimensional stability of the titanium foam.



CT slices before and after sintering



CT reconstruction of a Ø4mm titanium foam implant

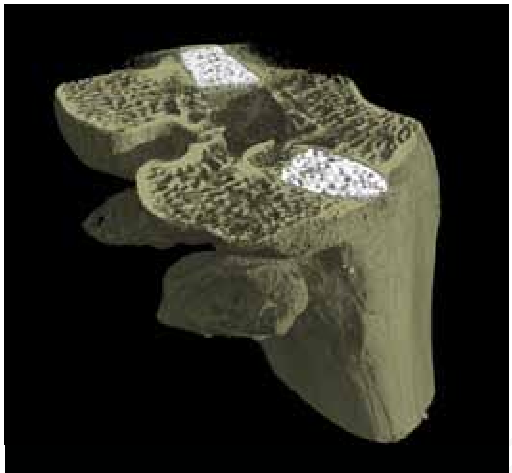
Developing stronger implants with a longer life

The 4 mm cylindrical titanium foam plugs were implanted in a rabbit femur at the Department of Orthopedic Surgery, McGill University Health Center, and after 6 weeks, the implants were extracted and encapsulated into a mounting resin. At this point, the focus of CT scanning shifts from material research to histology. To obtain long implant life, new bone structure should relatively easily expand into the pores of the titanium foam structure. This ensures solid implant locking and optimum load transfer between bone and implant.

CT-scanning visualizes the entire internal structure of the implant without damaging the specimens. High-resolution x-ray images generate accurate 3D digital volumes that serve as input for very detailed statistical investigations. In this regard, the pore surface occupied by bone tissue is of major interest. More detailed information includes the minimum/maximum pore size that contains bone. All this information can be retrieved efficiently using CT-scanning.

Better research though CT visualization technology

CT-scanning at highest resolution involves dazzling datasets and massive data processing. Data acquisition of the implant takes about 5 hours, while processing the data for 8GB volume reconstruction requires one additional hour. This is achieved using the stand-alone Nikon Metrology XT H system. More powerful processing hardware and software installed at NRC reduces data processing to only 5 minutes.

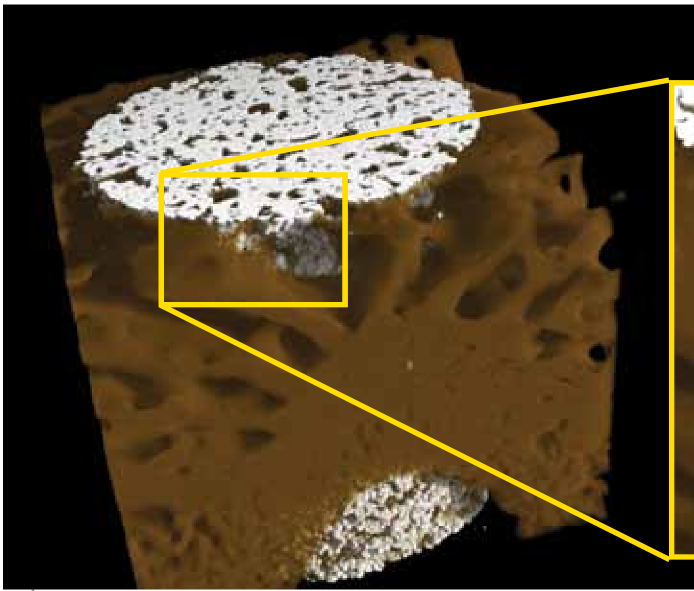


CT-reconstruction of the lower extremity of the implanted rabbit femur.

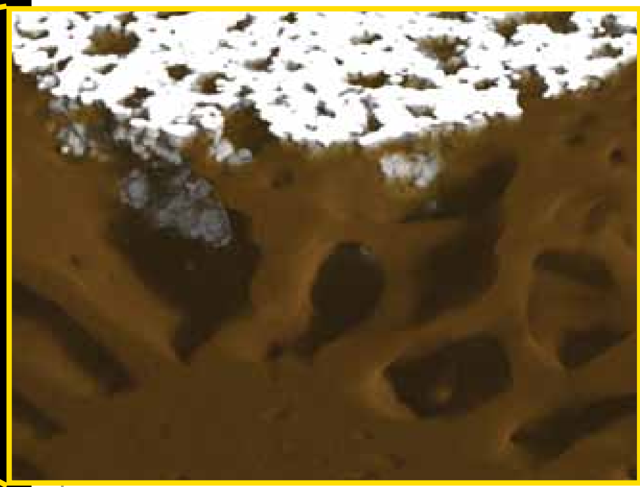
Nikon Metrology's XT H @ NRC

Industrial CT scanner visualizes small Titanium implant prototypes and investigates bone ingrowth

- Detailed volumetric imaging of porous implant foam structure
- CT scanner applied both for material research and histology
- Graphic data drives statistical investigation of foam pore size and bone ingrowth

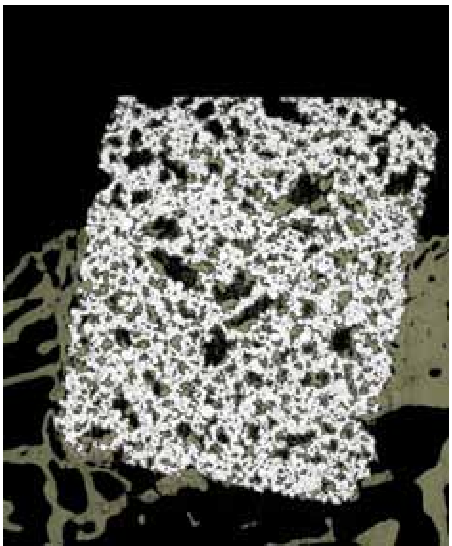


High-resolution CT-reconstruction of the implanted titanium foam (4.7 µm voxel size)



CT scanning reveals to what extent new bone structure has expanded into the pores of the implant foam structure

> *Micro CT allows researchers to study – in 3D, with increased speed, depth and precision – the behavior of porous material*



CT-slice of the implanted titanium foam.

On average, it takes about one working day to take the measurement, process the data, and perform initial observation. This compares favorably to the traditional destructive 2D visualization approach that consists of cutting and polishing the sample in order to observe the structure using light transmission or scanning electron microscope.

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More information about NRC can be found at
http://www.nrc-cnrc.gc.ca/index.html

More information about XT H can be found at
http://www.nikonmetrology.com/products/xray_ct_inspection/