

## A Study of Life Science Radiology and Material Synthesis with Synchrotron X-ray

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We have successfully developed the radiology with hard x-ray images and tomographic reconstructions - for very thick samples- in biology and medical research. In addition, the radiolytic reduction of gold precursor salt into gold nanoparticles under x-ray irradiation have been also developed.

### 1. Life Science Radiology

The most important key advantage of x-ray imaging is ability to examine thick samples nondestructively. For the first tomographic example, we investigate the surgical procedure female BALB/c mouse (age 10 weeks, weight 25 g) with a biocompatible ceramic (Hydroxyapatite) implants. To understand the bonding between this material and the newly developed bones is critical importance. Implants were cut into small pieces (0.5mm x 0.5mm x 0.5mm) and implanted into bone cavity of the left femur. The duration of implantation is eight weeks. After implantation, the mouse was sacrificed for the tomography analysis. The 3-dimensional images of this sample are shown in Figure 1. From Figure 1(b), one can see that the rectangular piece in the middle of the bone is the ceramic implant. In addition, the fine connection between the outside bone and the implant were newly developed. This result clearly reveals the different growth modes of the bone in response to the implants.

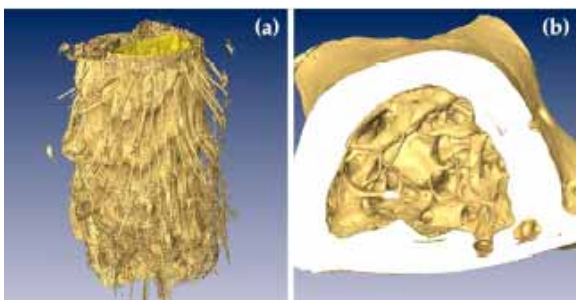


Figure 1. Tomographic 3-dimensional images of the internal structure of a mouse bone with a biocompatible ceramic (Hydroxyapatite) implant. a) shows the outside of a mouse finger joint revealing fine features of the bone and flesh; b) shows the details of the newly developed structure connecting the original bone and the implant.

Figure 2 shows another tomographic example: fine vessels of a few  $\mu\text{m}$  diameter can be clearly observed in the abdomen of a mosquito of size  $\approx 400 \mu\text{m}$ . Due to excellent spatial resolution (better than  $1 \mu\text{m}$ ) and deep penetration depth ( $> 1\text{mm}$ ), the volume selectivity is  $> 10^9$ . This high selectivity level sharply reduces the difficulties in sample preparing and interest finding.

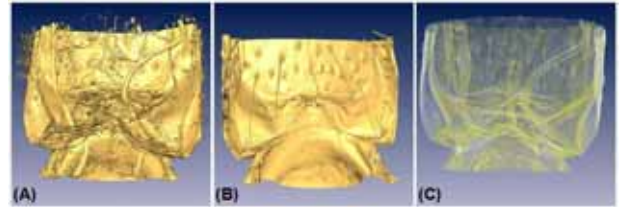


Figure 2. Tomographic 3-dimensional images of the of the abdomen of a mosquito. a) shows the inside of the abdomen with front surface of the abdomen as seen in b) removed (by software) and revealed fine vessels of a few  $\mu\text{m}$  diameter. c) shows volume rendered representation. The size of the abdomen of this mosquito is  $\approx 400 \mu\text{m}$ .

### 2. Materials Synthesis

A synchrotron based x-ray irradiation approach was developed to prepare colloidal gold aqueous solutions directly from gold precursor ions with controlled size and mono-dispersion. In this approach, appropriate amount of NaOH was also introduced into precursor solution to optimize the process. Without irradiation, the color of the sample remain unchanged, indicating that the Au ion would not be reduced, even after exposure to air for a few weeks. While the sample with irradiation for 90 sec, it become discolor, indicating that the Au particle would be reduced. In order to understand the actual Au particle size after irradiation, the sample was observed by TEM. From the TEM micrograph (Figure 3), we realize that the particle size of the sample with irradiation ranging between 10 to 20 nm.

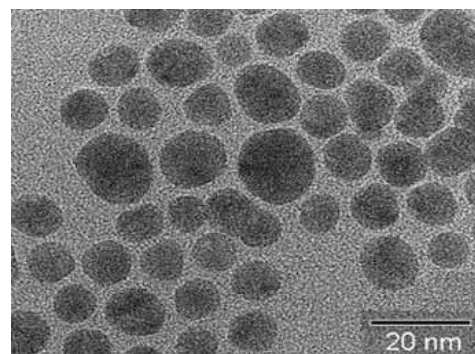


Figure 3. TEM image of synchrotron x-ray synthesized gold nanoparticles .