ESRF	**Experiment title:** Optimisation of dental restorations via 2D strain profile analysis of human dental enamel	**Experiment number**: 28 01 750
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Report:

Dental enamel is the most highly mineralised and strongest biological hard tissue. It comprises 95% hydroxyapatite (HA) mineral, 5% water, and 1% organic matter (non-collegenous protein). The hydroxyapatite crystal structure of dental enamel has been determined previously by several workers. HA has space group $P6_3/m$ with lattice parameters a=9.513Å and c=6.943Å. In all previous reports, the measurements were made on powdered enamel collected from many teeth, therefore any texture or strain information regarding the growth of the HA crystallites was lost. This information however is extremely valuable in the understanding of the formation of enamel, and in improved design of dental composites for restorations. Our recent experiment on XMaS for the first time mapped the change in preferred orientation as a function of position in an intact section of tooth (see XMaS Newsletter 2005).

In this latest experiment, we continued our study of texture, but also started to look at the effect of dental restorations on strain in tooth enamel. For each measurement, each tooth was divided into two parts, one part was drilled and restored by a qualified dentist, and the other part was left unrestored as a control. The two halves were then sliced into 500μm thick sections for the diffraction experiments. 2D diffraction patterns were collected using the MAR ccd detector every 150μm or 300μm in order to obtain 2-D images of the area of interest in each tooth section. Over the six days we collected diffraction images from healthy teeth, teeth filled with bulk material, teeth filled with a layered material, and several sections from the same tooth in order to reconstruct a 3D map of texture. It addition to these measurements, we also rotated a healthy tooth in order to study the strain via $\sin^2\psi$ plots. This technique is useful since it avoids the need to know the absolute strain-free lattice parameter value which can be difficult to determine.

Figure 1 shows the lattice parameter versus $\sin^2\psi$ for several positions through the tooth. The lines through the points are a guide to the eye. The colours correspond to the positions shown in Figure 2.

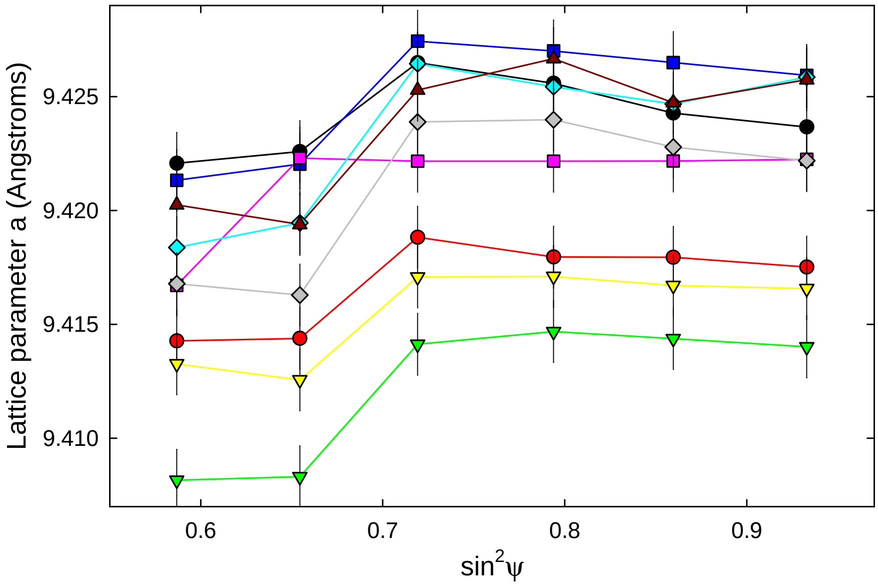

Figure 1 a-Lattice parameter vs $\sin^2\psi$ where ψ is the angle between the sample plane and the beam direction

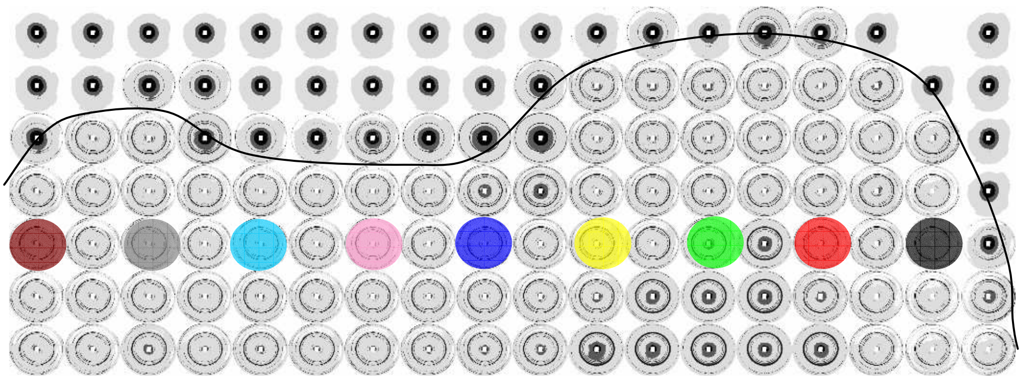

Figure 2 Composite map of 300μm spaced diffraction scans. The solid line indicates the outline of the tooth. The coloured scans correspond to the colours in Figure 1.

From Figure 1 it can be seen that there is not a clear trend in the lattice parameter change as a function of sample angle. This data is therefore inconclusive as to whether there is strain in the sample. However it does appear that there is a change in lattice parameter in different parts of the tooth. This result is confirmed by the analysis of data from our previous XMaS experiment (28-01-732). We are currently seeking further beamtime to determine whether this change in lattice parameter is due to changes in the crystal chemistry of the enamel tissue or whether it is due to strain in the sample – or a combination of both.

The data analysis involved refining greater than 1000 diffraction patterns; therefore an in-house automated batching procedure has been written and used to input the patterns into the GSAS Rietveld refinement software. With over 250Gb of data collected, work is ongoing to analyse the diffraction images from teeth filled with bulk material, teeth filled with a layered material, and several sections from the same tooth in order to reconstruct a 3D map of texture.