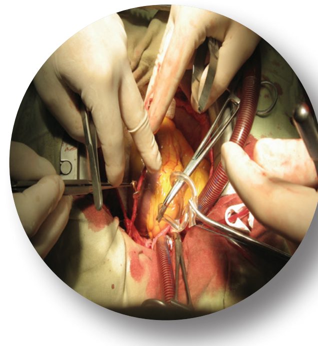
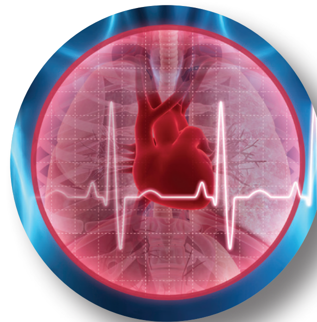
Case Study

What becomes of the broken heart valves?



The Problem

Artificial heart valves have been used since the 1960s to replace natural heart valves damaged through disease. Each of the four valves enables unimpeded blood flow through the heart itself and from the heart to the major arteries. As the heart beats the valve opens and closes, subjecting it to pressure loading and unloading. Artificial heart valves must be able to withstand repeated cycles of tensile loading and unloading in realistic biomedical conditions.



The Challenge

Thermoplastic elastomers have good elasticity and fatigue properties and are gaining popularity in biomedical applications. For these materials to be considered for use in prosthetic heart valves it is important to understand their behaviour under cyclic loading and unloading. Evidence of hysteresis during the process and the minimum number of pre-conditioning cycles before the material can be considered in steady state is also important. This evidence must be obtained from non-destructive structural measurements of the dynamic system operating in real time over many thousands of repeat cycles of loading and unloading.

The Solution

The non crystalline diffraction beamline, I22, at Diamond is ideally suited for study of soft condensed matter systems such as polymers and composites. The high intensity X-ray source coupled with the ability to make structural measurements on the millisecond timescale allows real time dynamic measurements. These dynamic measurements were used to evaluate the response of the material to mechanical stress and the reversibility of the response over an extended number of cycles.

The Benefits

The measurements allowed the research team to monitor microstructural evolution in real time, mimicking the beating of a prosthetic heart. The results obtained show that these novel materials may be suitable candidates for use in prosthetic heart valves.

"This study allowed us to examine the morphological evolution from the initial state to the stressed state and how this linked to the mechanical properties. We were able to observe real time micro-structural developments over the cycle time and over 10,000 cycles and measure the response of the material to applied mechanical stress on the ms timescale. It showed that these materials have both the long term stability and microstructural mechanical properties to be very promising for use in prosthetic heart valves."

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