GRADED POROUS TITANIUM FOR IMPROVED OSSSEOINTEGRATION INTO BONE IMPLANTS
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Introduction
For over fifty years, total joint replacement (TJR) has been a highly successful operation with good long-term results and an enormous increase in the quality of life of patients suffering from arthritis or related conditions. For these reasons, total hip replacement has been described as ‘the operation of the century’ [Learmonth, 2007]. However, there are approximately 10% of TJR that fail due to implant loosening because of poor bone ingrowth into the implant and mechanical mismatch between the implant and the bone. This project aims to use Electron Beam Melting (EBM) [Heinl, 2007] to create lattices with graded porosity, to investigate their mechanical properties and to assess their potential for improved bone ingrowth in vivo.

Methods
CAD models of three non-graded lattices with different strut diameters and one graded lattice with three layers of different strut diameter were designed. All lattices consisted of 2 mm side length diamond unit cells. The lattices were built on an EBM-S12 (Arcam) using powdered titanium alloy. Mechanical testing was done by uniaxial compression and the resulting stress-strain curves were used to calculate the Young’s modulus and the yield strength. Cells were statically seeded on the lattices and grown for three weeks under static or dynamic conditions to investigate whether mechanical stimulation has an effect on the quality of the extracellular matrix.

Results
All models were built as described; the graded lattice was examined using SEM (fig. 1). Analysis showed that the strut diameters were 400, 600 and 770µm. The Young’s modulus of the graded structure was compared with non-graded lattices that had the strut diameter of the individual layers (fig. 2).

Discussion
It is possible to use EBM to create porous titanium lattices with graded porosity that have the potential to be used in bone implants to improve implant fixation. The Young’s modulus of the materials is close to that of natural cancellous bone; this may reduce the risk of bone resorption due to stress shielding. Bone-like matrix can be formed on these lattices; future work will assess long term bone ingrowth.

References