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論 文 要 旨
THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Titanium and its alloy, especially Ti-6Al-4V have been widely used for biomaterial, especially bone implant, because of its high specific strength and excellent corrosion resistance. Big difference of Young's modulus or Modulus of elasticity between bone and this alloy has been a great concern for bone implants. This big difference of Young's modulus can cause the absent or less stress at the bone as the consequences of stress concentration on the metal implant as the stronger part of the structure, namely stress shielding. This present thesis mainly discussed the fabrication of porous Ti-6Al-4V through space holder method and the influence of heat treatment to porous Ti-6Al-4V in order to produce low Young's modulus of metal implant with compatible strength value to cortical bone properties which are around 10 – 30 GPa of Young's modulus and 70 – 280 MPa of compressive strength.

In order to obtain the effective condition of fabrication of porous Ti-6Al-4V, the influence of sintering parameters, space holder size and its distribution to the formation of macro- and micro-porosity were investigated. It was found that space holder distribution plays an important role to increase open porosity value of porous products. Open porosity of sample increase as the more homogenous space holder distribution produced suggests distribution of space holder is main aspect that control the macro-pore interconnectivity. There is no significant increase of open porosity number by varying the space holder size and shape implying the interconnectivity between macro-pore is independent on space holder size and shape. Additionally, sintering temperature and pressure are the main parameter to control micro-porosity. Increasing sintering pressure is more effective to reduce micro-porosity in the samples. Relative density produced is independent on heating rate. The most effective condition to produce less micro-porosity and more interconnected macro-porosity is utilization of any kind of space holder size with the addition of 10 wt. % ethanol as PCA and sintering at 700 °C, 60 MPa.

In the relation of porous products' mechanical properties, macro-porosity in the range of 50 – 800 μm plays more significant role to control mechanical properties of porous product. Irregular shape of macro-pore result about two times lower mechanical properties than cuboidal shape macro-pore while porous mechanical properties is insensitive to macro-porosity size. Homogenous macro-porosity will result more pore connectivity which result to higher number of open porosity and lower Young's modulus. Porous product strength is more dependent to pore wall thickness than its open porosity number. Micro-porosity in the size a few till a few ten micrometer has no significant effect to both Young's modulus and mechanical properties of porous product.

Before doing heat treatment to porous products, solution treatment and aging were performed to spark plasma sintered Ti-6Al-4V. It was found that upon quenching, martensite phase only formed by sample solution treatment above 980 °C. Due to quite high vanadium content which stabilized the BCC structure, quenching below such temperature produced metastable

β phase. Aging treatment enhances formation of β phase precipitate. Thus, after aging martensite decomposes to rich vanadium β phase, which form along the grain boundary of martensite and aligned along interface of martensite plate, and lean vanadium α-phase. The decomposition then decrease the hardness of the sample. The results of solution treatment also imply that the β transus temperature of spark plasma sintered Ti-6Al-4V is higher than 1050 °C.

Finally, the influence of solution treatment and oxygen to microstructure and mechanical properties of Porous Ti-6Al-4V are investigated. Oxygen content affects the phase's constituent of porous sample at elevated temperature. Due to relatively high oxygen content the β transus temperature of the sample increase till between 1200 and 1300 °C. Even though oxygen increase the β transus temperature, it also increase the compressive strength of porous sample. Solution treatment at temperature 850 – 1000 °C followed by ice water quenched produces microstructure which is similar to spark plasma sintered Ti-6Al-4V and increases the mechanical properties of porous Ti-6Al-4V. Solution treatment at single β phase area at 1300 – 1400 °C produce a very fine Widmanstätten α and β phase which successfully results to the increase of mechanical properties of porous Ti-6Al-4V, compatible with cortical bone properties.