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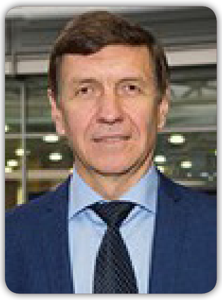

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Towards design and manufacturing of biomedical implants with biological fixation: Development of an integrated numerical model

In recent years, orthopaedic implant research has been driven by biological fixation. In this type of fixation, a layer of biologically active material on the implant surface generates interfacial bonding between the implant and bone. The presence of bio-active material with appropriate level of porosity and crystallinity influences host bone regeneration by creating an environment allowing for cell spreading, proliferation and subsequent bone formation integrating the implant into the body. Their clinical applications are limited to non-load bearing implants due to brittleness and relatively poor mechanical properties. Multilayered coating of a mechanically tough substrate is an alternative route to reduce the risk of early implant failure. Faster and cheaper fabrication of such implants is expected with laser-assisted densification of multiple materials via additive manufacturing (AM) technology. The process is being developed to fabricate implants made of multiple materials in one operation without part-specific tooling and human intervention. Such implants having increased longevity provide more secure fixation using tailored properties, which cannot be achieved by conventional manufacturing techniques. There are many factors that can influence a laser assisted AM of the implants reflecting in enhancement of their biological fixation. There appears to be no clear understanding of the cooperative relationships between different physical phenomena taking place in the manufacturing process on different scales of consideration. There is also lack of mathematical models, which could predict and link them with the macro- response of the multi-layered structures. This lack of relevant knowledge is the serious obstacle on the way towards reliable manufacturing and successful clinical use of such multi-layered implants made by AM methods. The paper presents resent advances on development of an integrated model including specific mechanical, optical, thermal, thermo-mechanical, metallurgical and chemical phenomena taking place in the laser-assisted multi-material AM. Most importantly, the development of such multiscale numerical model, which can support the design and manufacture of such novel implants, is multidisciplinary enterprise involving material design, implant design and fabrication, biological and clinical assessment among others. An establishment of an appropriate platform for cooperation between relevant institutions including universities, hospitals and enterprises to facilitate research, development, preclinical and clinical studies is crucial.

Recent Publications

1. Svyetlichnyy D et al. (2018) Application of cellular automata and Lattice Boltzmann methods for modelling of additive layer manufacturing. International Journal of Numerical Methods for Heat & Fluid Flow. 28(1):31-46.
2. Krzyzanowski M et al. (2016) 3D analysis of thermal and stress evolution during laser cladding of bioactive glass coatings. Journal of the Mechanical Behavior of Biomedical Materials. 59:404-417.
3. Krzyzanowski M et al. (2016) Powder bed generation in integrated modelling of additive layer manufacturing of orthopaedic implants. International Journal of Advanced Manufacturing Technology. 87(1-4):519-530.

Biography

Michal Krzyzanowski is currently a Professor of Engineering and Materials Science at Birmingham City University, UK. He has served and is currently on many International Conference Scientific/Executive Committees and is also a Fellow Member of the Institute of Materials and Mining, UK. He has co-authored of over 150 publications including one book, research monograph and several book chapters. His current research interests include also processing of nanocrystallized multilayered metallic structures and development of physically based modelling methodologies for investigation of multiphysical phenomena in additive manufacturing.

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