Trimačių stiklo-keramikos mikro- ir nanodarinių gamyba panaudojant tiesioginį lazerinį rašymą ir pirolizę

Fabrication of Tri-dimensional Glass-Ceramic Micro- and Nanostructures using direct laser writing and pyrolysis

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Ceramics play an important role in today's science and industry as it can withstand immense heat, mechanical and other hazards. Consequently, there is a need to find ever-new ways to acquire more sophisticated free-form 3D ceramic structures. Recently, stereolithographic 3D printing of hybrid organic-inorganic photopolymer and subsequent pyrolysis was demonstrated to be capable of providing true 3D ceramic structures [1]. However, such approach was limited to millimeter scale, while one of the aims in the field is to acquire functional 3D glass-like structures in micro- or even nano-dimensions, respectively.

In this paper, we explore a possibility to apply ultrafast 3D laser nanolithography [2] in conjunction with pyrolysis [3] to acquire ceramic 3D structures in micro- and nano-scale. Laser fabrication allows production of initial 3D structures with relatively small (hundreds nm) feature sizes out of hybrid organic-inorganic material SZ2080 [4]. Then, a post-fabrication heating at different temperatures up to 1000 ^{o}C in Ar andair atmospheres decomposes organic part of the material leaving only the glass-ceramic component of the hybrid. As we show, this can be done to 3D woodpiles [Fig 1] and bulk objects. We uncover that the shrinkage during sintering can reach up to 40%, while the aspect ratio of single features as well as filling ratio of the whole object remains the same. This hints at homogeneous reduction in size that can be easily accounted for and compensated before manufacturing. Finally, thermal gravimetric analysis (TGA) and Fourier transform infrared micro-spectroscopy measurements are performed in order to uncover undergoing chemical and physical phenomena during pyrolysis and composition of the remnant material.

The presented results suggest that the combination of 3D laser nanolithography and pyrolysis can be applied to great effect in creating glass-ceramic structures as well as downscaling their dimensions. This can be used in creation of highly resilient ceramic micronano-optical elements [5] or photonic lattices with ultra-fine internal periods and features [6].

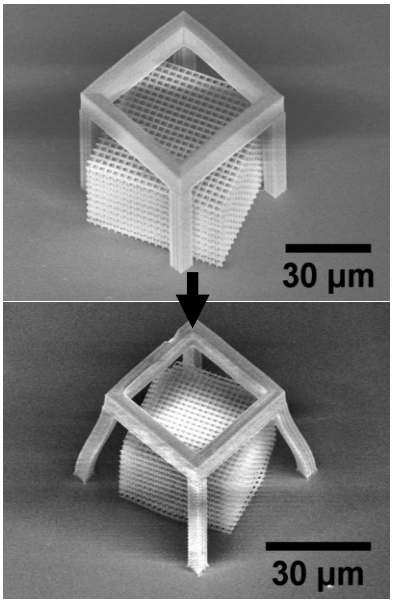

Fig. 1 A woodpile made from SZ2080 that has beend concistently shrunk down through the use of pyrolysis.

Reikšminiai žodžiai:direct laser writting, pyrolysis, SZ2080, polymer.

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