IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Laser Based New Materials Design and Manufacturing: Integration of Nano/Micro Functional Structures

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Abstract

Integration of manufacturing, with mobile internet, cloud computing, big data, bioengineering, new energy, and new materials is triggering new production methods, industrial forms, business models and economic growth points. Great effort has been put to technological innovation and promoting new breakthroughs in additive manufacturing (3D printing), laser manufacturing, biomanufacturing, etc. However, the manufacturing of refractory materials such as ceramic and high entropy alloy are still difficult to practice. This class of refractory materials, with extraordinary properties in resilience and strength, are famous for their higher performance while simultaneously infamous for their difficulty to engineer. Unblocking the additive manufacturing (AM) of this family of materials will be widely appreciated by materials researchers *(1)*, AM developers, and the users of refractory parts in various application spanning from bio-medical engineering, energy power plants, to aerospace. Meanwhile, the most reliable method for AM at sub-micron to 100nm scale is still limited to polymer based two photon polymerization (2pp) at high cost. Manufacturing of structures made of other materials using 2PP all requires post coating, deposition or thermal treatment. Laser, as a powerful tool with intriguing thermal and optical effects, will bring new opportunities for developing low cost versatile methods with broad materials inclusivity and wide spacial resolution.

By precursor materials engineering, we developed a large-scale, cost-effective direct pattern method manufacture 3D ultrathin transition metal carbide structures with hierarchical nano-micro porous structures (macroporous, ~10–20 nm wall thickness, ~10 nm crystallinity). Besides high energy storage capability and exceptional higher thermal resilience of laser induced carbide, the sculptured 3D structure can tune the optical and transport properties by engineering the pore distribution *(2-3)*. Laser printing process also enable the integration of functional carbide on stretchable and foolable structure such as paper origami which greatly broaden their application in sensors and wearable electronics *(4)*. With the help of atomic scale simulation of laser induced chemistry and Multiphysics, we can future design the laser engineering process to empower old materials with new opportunities. For example, using laser annealing process as a variable and scalable tool, we transform natural carbonaceous (coal, tar, pitch) as a toolbox for target carbon product with highly tunable crystalline structures from amorphous to graphitic and widely distributed electronics conductivities *(5)*.

References: 1. **X. Zang*** *et al.*, *Nat. Commun.* **10**, 3112 (2019). 2. C. Jian, S. Merchant, **X. Zang***, N. Ferralis*, J. C. Grossman*, *Carbon N. Y.* **155**, 309–319 (2019). 3. **X. Zang*** *et al., Adv. Mater.* **30**,1805188 (2018). 4. **X. Zang*** *et al.*, *Adv. Mater.* **30**, 1800062 (2018). 5. O. P. Morris, **X. Zang**, *et al.*, *Adv. Mater.* 1900331 (2019).

Biography

Dr Xining Zang is a postdoc researcher in Department of Materials Science and Engineering in Massachusetts Institute of Technology. Dr. Zang got her PhD from University of California Berkeley in 2017 August. During PhD she worked on 2D materials synthesis and assembly to nanostructured device, which span from wafer scale manufacturing and integration of 2D materials including transition metal chalcogenide and transition metal carbides for electronics and energy related applications (catalyst, battery and supercapacitors). Currently, she is working on laser manufacturing of refractory metal and carbide, and laser engineering of natural carbonaceous materials (coal, tar, and etc) for electronics devices.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.

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