ZHIGANG ZAK FANG

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Highlights of Experiences and Accomplishments

- Successful faculty entrepreneur. **Commercialized two technologies** through two separate spinoff companies.
- **Google Scholar**: https://scholar.google.com/citations?hl=en&user=5YjgjOwAAAAJ As of September 17, 2025: Citations 13,479 · h-index 61 · i10-index 171
- **Program Director, USDOE** Advanced Research Project Agency-Energy (ARPA-E), 2019-2022
- Experiences in industry (11), academia (23), and government (DOE, 3 years)
- **Total funding to date ~$37MM**, incl. govt fund $22M. PI and Director of seven large DOE-funded multi-organization programs.
- Fellow of the National Academy of Inventors. Inventor of over 60 US patents.
- Two-time R&D 100 Awards: 2009 and 2023 for tungsten carbide and titanium, respectively.
- Humboldt Research Award.
- Fellow of the American Society of Metals (ASM) International and the American Powder Metallurgy Institute (APMI) International, respectively.
- Editor-in-Chief, Int. J. Refractory Metals and Hard Materials, Elsevier
- Books: Extractive Metallurgy of Titanium, Elsevier Publishing, 2018, and Sintering of Advanced Materials, Elsevier/Woodhead Publishing, U.K., 2010.

Experiences

- 2025 – Present: Ivor Thomas Endowed Chair Professor, Department of Materials Science and Engineering / Metallurgy, University of Utah
- 2019 – 2022: Program Director, U.S. Department of Energy, Advanced Research Projects Agency–Energy (ARPA-E)
- 2013 – 2024: Editor-in-Chief, International Journal of Refractory Metals and Hard Materials, Elsevier
- 2002 – 2025: Professor, Metallurgical Engineering / Materials Science & Engineering, University of Utah (Asso. Prof, 2006–2010; Assis. Prof, 2002–2005)
- 1997 – 2002: Director, Materials R&D, Smith Bits, Smith International (Schlumberger Inc.)
- 1994 – 1997: Manager, Materials Research, Smith Tool, Smith International
- 1991 – 1994: Senior Materials Engineer, R&D, RTW, Greenfield Industries (Kennametal Inc.)
- 1986 – 1987: Research Fellow, Delft University of Technology, The Netherlands
- 1985 – 1986: Assistant Professor of Powder Metallurgy, Beijing University of Science and Technology, China

Education & Professional Preparation

- Ph.D., Materials Science and Engineering, University of Alabama at Birmingham, 1991
- M.S., Materials Science and Engineering, Beijing University of Iron & Steel Technology (now USTB), 1985
- B.S., Materials Science and Engineering, Beijing University of Iron & Steel Technology, 1982
- Executive Education: Manufacturing Program, Johnson School of Business, Cornell University, 1996

Research Achievements, Experiences, and Expertise

Titanium, Titanium Alloys, Titanium Hydride, and Titanium Dioxide

- **Commercialized a breakthrough low-cost process for the production of Ti primary metal -** Lead inventor of the Hydrogen-Assisted Magnesiothermic Reduction (**HAMR**) process for producing primary titanium from ore concentrates. First major alternative to the 70-year-old Kroll process: 40% more energy efficient, potentially 100% renewable, carbon-free, and 30–70% lower in cost. Commercialized by IperionX (IPX), which has raised over $200M in four years, including U.S. DoD contracts, and built an ~800,000 sq. ft. facility with 1,400-ton annual capacity. Disruptive impact on defense, aerospace, energy, and consumer electronics industries, with multi-billion-dollar economic and significant environmental benefits.
- **Commercialized an innovative sintering process for manufacturing high-performance, low-cost titanium and titanium alloys -** Invented the Hydrogen Sintering and Phase Transformation (**HSPT**) process for titanium alloys. It produces fine-grained, fatigue-resistant alloys without conventional energy-intensive methods. In combination with HAMR, it reduces cost by 30–70% and strengthens U.S. titanium manufacturing competitiveness. Currently being commercialized by IperionX.
- **Commercialized a new process for making spherical Ti alloy powder** – Invented the granulation-sintering-deoxygenation (GSD) process for the production of spherical titanium alloy powder for 3D printing. It is 5-70 lower cost than the conventional atomization processes. Enabled the additive manufacturing of Ti alloys to be done cost-effectively.
- **Invented and patented an additional 7 US patents related to Ti**, including a new process for making TiO_2 more energy efficient, deep deoxygenation of Ti, a combination of electrochemical and thermochemical methods for production of Ti, Ti porous transport layer for electrolyzers, a sinter-HIP process for full density and fine grain Ti, a method for additive manufacturing of Ti, among others.

Cemented Tungsten carbide, refractory metals, polycrystalline diamond, and other hard materials

- **Invented and commercialized the functionally graded carbide technology** - improving WC-Co tool durability by 30–100%. Licensed to leading companies in the U.S., Europe, and China. Direct U.S. sales exceed $100M; indirect global productivity impact >$1B. Tungsten carbide accounts for ~80% of tools used in global metal machining and rock drilling.
- **Invented "double cemented tungsten carbide"** composite while working for Smith International Inc (Sii) (Schlumberger). Improved the fracture toughness and impact resistance by >50%. Manufactured and marketed by Smith International, Inc.
- Developed a "functionally designed polycrystalline diamond composite". Manufactured and marketed by Sii.
- Developed nano and ultrafine grain hard metals
- Developed hardfacing materials for rock drill bits. Manufactured and Marketed by Sii.
- Developed polymer/rubber composite seals for rock drill bit. Manufactured and marketed by Sii.

Additive Manufacturing

- Established the largest Center for Additive Manufacturing in the state of Utah. The center has four metal 3D printing machines based on a range of different technologies, including laser powder bed fusion (LPBF), direct energy deposition (DED), binder-jet printing, and lithography-based metal printing or sinter-based AM.

Ferrous Powder Metallurgy and Advanced Materials Processing

- Funded by the USDOE/ARPA-E for a new process for the production of iron powder and steel products directly from iron ore concentrate. The new sustainable process technology can reduce the energy consumption of iron and steel production by more than 40% without sacrificing mechanical performance properties.

Sintering - Ultrafine/nano-grain tungsten, tungsten alloys, and other refractory metals

- Developed and published extensively on the sintering of nanosized powders.
- Develop a process for processing and sintering of nanosized WC-Co powder. The work contributed to the worldwide adoption of ultrafine-grain WC-Co materials for the manufacturing of microdrills for the manufacturing of electronic circuit boards. The indirect impact of the microdrills continued from the late 1990s till today.
- Developed the processes for processing and sintering of nanosized tungsten metal powders. Manufactured the first nanostructured tungsten material in the world for the first wall plasma-facing components in a fusion reactor. The material was tested by Sandia National Lab in a DIII-D fusion environment reactor and achieved instructive results, which were published.

- Developed a process for improving the fracture toughness of ultrafine-grain tungsten. The fracture toughness of ultrafine-grain tungsten was improved by 100% using the new method.
- Developed and published a comprehensive theory on the coalescence, sintering, and grain growth of nanosized particles.

Metal Hydride for hydrogen storage and thermal energy storage applications

- Developed a thermal battery that can provide heating and cooling based on the hydriding and dehydriding of metal hydrides. The thermal battery was developed for HVAC unit for electric vehicles. The technology was showcased by ARPA-E during its annual meetings.
- Developed a reversible metal hydride material, LiMgN, that can reversibly store hydrogen at moderate temperature, outperforming most other candidate materials considered for such applications. Thermal energy storage based on metal hydrides
- Investigated the mechanisms and established a theory on the activation process of TiFe for hydrogen storage. This is one of the best materials considered for stationary hydrogen storage applications.

ARPA-E/DOE Leadership

- As ARPA-E (US DOE) Program Director (2019–2022), initiated and led the creation of the ULTIMATE program (Ultrahigh Temperature Impervious Materials Advancing Turbine Efficiency). Advanced alloys designed for continuous operation at >1300 °C, surpassing Ni/Co superalloy limits. Integrated high-entropy alloys, advanced modeling, and additive manufacturing. Supported 17 teams across U.S. universities, labs, and industries. Recognized as transformative in energy efficiency, carbon reduction, and high-temperature materials research. Inspired subsequent programs at DARPA and the U.S. Army.
- Managed high temperature and high-pressure exchanger (HITEMPP) program that focused on energy efficiency of heat exchangers in industrial systems, leveraging advances in computational topological designs, advanced high temperature alloys, and additive manufacturing.
- Managed multiple materials and manufacturing projects for advanced nuclear energy programs.
- Managed total funding of nearly $100M

Awards and Honors

- Humboldt Research Award, 2023. Germany's most prestigious research honor, recognizing global excellence in physical science and technology.
- Fellow, National Academy of Inventors (2017)
- Fellow, ASM International (2017)
- Fellow, APMI International (2015)

- MPIF Distinguished Service Award (2019)
- Utah Innovations Award (2010, 2018)
- Editor-in-Chief, Int. J. Refractory Metals and Hard Materials (2013–2024)
- University of Alabama at Birmingham Engineering Alumni "40 Engineers Making a Difference" Award (2011)
- Best Poster Award, Sintering 2011 (Jeju, Korea)
- Teaching Award (2004/2005), Dept. of Metallurgical Engineering, University of Utah
- First Place, ASM International PM Metallographic Contest (2002)

Invited lectures, presentations, and activities

- TMS 2025 EPD/MPMD Luncheon speaker
- Keynote, World PM Congress, Yokohama, Japan, October 2024
- Keynote, PM and AM of Ti, Madrid, Spain, September 2024
- Keynote Speaker – Powder Metallurgy and Additive Manufacturing of Titanium 2022, Montreal, Canada
- Invited Seminar Speaker, Dept of Materials Sci and Eng, MIT, November, 2019
- Keynote Speaker – Powder Metallurgy of Titanium 2017, Xi'an, China
- Keynote Speaker – World PM Congress, 90 Years of Hardmetals Celebration, Hamburg, Germany, October, 2016
- Plenary Speaker – Int. Symp. Novel and Nano Materials 2016, Budapest, Hungary, July 2016
- Invited Speaker – Ti Round Table 2016, Hokkaido, Japan, July 2016,
- Invited Speaker – MS&T 2016, Sintering Symposium, Salt Lake City, UT, USA
- Invited Speaker – Third PM Ti 2015, August 2015, Luneburg, Germany
- Invited Speaker – TMS 2015, Plenary on Light Metals Production, Orlando, Mar. 2015
- Invited Speaker – Sintering 2014, August 2014, Dresden, Germany
- Invited Speaker – Metal-Hydrogen System (MH2014), July 2014, Manchester, U.K.
- Keynote address – 18th Plansee Seminar, June 2013
- Invited Speaker – TMS 2013 Cost Affordable Ti Symposium, San Antonio, March 2013
- Invited Speaker – MS&T 2012 Powder Ti Symposium, Pittsburgh, PA, October 2012
- Invited Speaker – MS&T 2012 Energy Materials Symp. Pittsburgh, PA, October 2012
- Invited speaker – TMS 2012, R. German Honorary Symposium
- Invited speaker – PM Ti Brisbane Australia, December 2011
- Invited speaker – MS&T 2011, K. Chawla Honorary Symposium
- Invited seminar speaker – Argonne National Lab, August 2011
- Invited speaker – Sintering 2011, Jeju, Korea
- Invited speaker – World Congress of Powder Metallurgy 2010, Florence, Italy
- Invited speaker – MS&T 2009, Nano Material Processing Symp., Pittsburgh, PA
- Invited speaker – AsiaNano 2008, Singapore
- Invited speaker – Material Innovation In H_2 Economy, Acers, Cocoa Beach, 2008
- Invited speaker – Beijing University of Sci. and Tech, June 2011
- Invited speaker – Kunming University of Sci and Tech, July 2009

Professional Services and Societies

- TMS – The Minerals, Metals & Materials Society
- ASM International
- APMI International
- Chair, TMS Powder Materials Committee
- Editor-in-Chief, Int. J. Refractory Metals and Hard Materials
- Editor and author, Extractive Metallurgy of Titanium, Elsevier 2018
- Editor and Contributor, Sintering of Advanced Materials, Woodhead Publishing, Cambridge, UK, 2010
- Editorial Review Committee, Int. Journal of Powder Metallurgy
- Editorial Board, Powder Metallurgy, Maney Publishing
- Invited Symposium Organizing Chair, Hydrogen Storage and Carbon Capture, MRS Spring Meeting, 2011
- Invited Special Program Chair, EPMI, P/M World Congress, 2010.
- Session Organizer and Chair, Technical Program Committee Member, MPIF, 1999 – 2010
- NSF Division of Engineering, Committee of Visitors (COV)
- NSF Sustainable Energy Review Panel / Mail, 2007, 2008, 2011
- NSF multiple review panels: 1995, 1996, 2002, 2003, 2006, 2007, 2008, 2009, 2010
- Reviewer: DOE-BES, DOE-NETL, U.S. Army Research Office, and others
- Peer review: multiple international journals: Nature Communications, Acta Materialia, Journal of the American Chemical Society, Advanced Materials, Advanced Functional Materials, Journal of the American Ceramic Society, International Materials Review, J. of Physical Chemistry, J. of Materials Science, J. of Alloys and Compounds, Materials Science and Eng, J. of Materials Eng. And Performance, Int. J. Powder Metallurgy, Chemistry of Materials, In. J of Refractory Metals and Hard Materials, etc.

Publications & Patents (separate list of publications and patents available)

• 2 books; 195 peer-reviewed journal articles; 350 total publications and patents.

• >60 U.S. patents to date. Inventor/co-inventor of 60+ U.S. patents