Dr. Liangbing Hu

Distinguished University Professor and Director of Center for Materials Innovation
Department of Materials Science and Engineering, University of Maryland
4418 Stadium Drive, College Park, Maryland 20742. 240-478-3268 (phone), binghu@umd.edu
Google Scholar: https://scholar.google.com/citations?user=aYbwgSMAAAAJ&hl=en&oi=ao
https://mse.umd.edu/clark/faculty/669/Liangbing-Hu

Experience:

2023-Present:	Distinguished University Professor, Department of Materials Science and Engineering, University of Maryland, College Park, MD
2020-2023:	Herbert Rabin Distinguished Professor, Department of Materials Science and Engineering, University of Maryland, College Park, MD
2019-2020:	Minta Martin Professor of Engineering, Department of Materials Science and Engineering, University of Maryland, College Park, MD
2016-2019:	Associate Professor (with Tenure), Department of Materials Science and Engineering, University of Maryland, College Park, MD
2011-2016:	Assistant Professor, Department of Materials Science and Engineering, University of Maryland, College Park, MD
2009-2011:	Postdoctoral Researcher, Department of Materials Science and Engineering, Stanford University, CA
2006-2009:	Founding Scientist, Unidym Inc., Menlo Park, California, CA
2003-2007:	Research Assistant, Department of Physics, University of California, Los Angele, CA

Education:

University of California, *Los Angeles*, CA
Ph.D. in Physics, 2002−2007
University of Science and Technology of China (USTC), Anhui, China
B.S. in Physics, 1997−2002

Research (Selective):

- ***Engineered Wood Through Nanoscale Engineering***
  In the past 12 years at UMD, my research group has made a few original, high-impact contributions to engineered wood technologies.

  - Invented super strong and tough wood (Super Wood, stronger than steel, but six-times lighter, *Nature*). The Super Wood research has been widely reported in many media including BNN Bloomberg, VOA news, New York Post, Scientific America and many others. This technology won the R&D 100 Award in 2019, widely recognized as the "Oscars of Invention." The research received $4M in research funding from DOE ARPA-E to scale up the manufacturing of Super Wood for energy-efficient lightweight vehicle applications. In 2023, my startup company, InventWood LLC, received **$20M** ARPA_E SCALEUP (the largest DOE ARPA_E grant) funding to scale up the manufacturing and commercialization of Super Wood technology.
  - Invented transparent wood (a transmittance of > 92%, a low thermal conductivity 1/6 of glass, and better mechanical toughness and light guiding effects, Advanced Materials, 6, 22, 2016). This transparent wood has been broadly covered by mass media, including CNN, Yahoo Finance, Insider, Science Alert, Phys. Org., *etc*.

- Invented cooling wood (achieving interior temperatures of up to 9 ºC below ambient, *Science*, 364, 760, 2019). While other radiative cooling materials have been demonstrated (e.g., dielectric coating layers, metallized polymer films, and even organic gases), it remains a challenge to both manufacture and apply these structures at the size and scale required for construction purposes. I led an engineering strategy to tailor the optical and thermal properties of wood to achieve a high-performance radiative cooling effect. The multiscale fibers and channels function as randomized and disordered scattering elements for an intense broadband reflection at all visible wavelengths. Meanwhile, the molecular vibration and stretching of chemically treated cellulose in cooling wood facilitate strong emission in the infrared. This invented cooling wood has been reported by Xinhua Net, Chemial & Engineering News, MIT Technology Review, The India Express, Phys. Org. and others.
- Invented moldable wood that can be shaped like plastic and metal (*Science*, 374, 465, 2021; Cover). Wood is a sustainable structural material, but it cannot be easily shaped while maintaining its mechanical properties. I led an invention that that uses cell wall engineering to shape flat sheets of hardwood into versatile three-dimensional structures. This approach widens wood's potential as a structural material, with lower environmental impact for buildings and transportation applications. This moldable wood has been covered by media including Chemical & Engineering News, Yahoo News, Physics World, Chemistry World, Daily Magazine News and others.
- Invented thermal insulating nanowood (Science Advances, 4, 3, 2018). The material features a low thermal conductivity of ~0.03 W/m·K. When compared with synthetic, nonrenewable structures (e.g., Styrofoam), the Insulating Nanowood possesses a similar thermal conductivity but significantly higher mechanical strength (highlighted in the *Los Angeles Times*, and the 2018 HIVE 500 Building Tech Award Winner). Other media have also reported this work on insulating nanowood, including Phys. Org., Nova Next, Inverse, Europa Press, Physics World, *etc.*
- Invented wood cellulose batteries (Nature, 598, 590, 2021; patent). Opening the molecular channels between the cellulose chains through Cu^{2+} coordination, my group achieve a Li-ion conductivity as high as 1.5×10^{-3} S cm^{-1} at room temperature—a record among all known polymer ion conductors. My group was awarded a $2.6M DOE ARPA_E grant to further develop solid-state battery technology using these Cu-Cellulose-based ion conductors. This work has been broadly covered by media including Physics World, Nature, Yahoo, Green Car Congress, AZO Materials, Eco Inventos, Science Magazine and others.

- ***Ultrahigh Temperature Synthesis:***
  Pioneered ultrahigh-temperature synthesis through multiple inventions, including ultrafast high-temperature sintering (UHS) for bulk ceramics and thermal shock for high entropy nanoparticles. He has published extensively in this research direction since 2016, with > 90 publications in top journals, including two *Science* cover articles and two *Nature* articles.

- Discovered high entropy alloy nanoparticles synthesized by a rapid, ultrahigh temperature shock method (Science, Cover). This was the first report of high entropy nanostructures with uniformly distributed atoms in nanoparticles with a diameter of just a few nanometers. This work has been widely reported by media, including Materials Today, Science, EurekAlert (AAAS), Science Daily, among others.
- Extended the high temperature shock synthesis to various compositions and different temperature/time profiles to achieve intermetallic (Science Advances), high entropy oxide (Nature Catalyst), and metallic glass structures (Nature), which are technologically important for catalyst applications but were previously impossible to obtain until now. These catalysts show great promising in various catalytic applications, such as ammonia oxidation (Science), ammonia decomposition (Nature Commun.), nitrate reduction (Nano Letter), and methane (Nature Catalyst, Cover).
- Invented ultrafast high-temperature sintering (UHS) as the leading inventor (Science, Cover). This exciting breakthrough allows various ceramics to be sintered in just 10 seconds, which is ~1000-times faster than conventional sintering processes, which often take ~10 hours. This technique can greatly

accelerate the screening and discovery of high-performance ceramic materials, and it may have a huge impact on multiple technological fields, including solid-state batteries, 3D printing, and high-temperature structural ceramics. This work has been widely reported by media, including Yahoo, Chemical & Engineering News, Nanowerk, Science Daily, Eurek Alert, and others.

- Invented programmable heating and cooling method for the non-equilibrium synthesis of thermo-chemical reactions for ammonia synthesis (Nature, Cover) and plastic upcycling (Nature). The dynamic heating process helps prevent the agglomeration of the nanoparticle catalysts. These works have been highlighted by Nature Synthesis, Packaging Insights, Chemistry World, Nature Podcast, Phys. Org, Nature Physics, among others.

Awards and Recognitions:

- 2023 Distinguished University Professor
- 2023 the Senior Faculty Outstanding Research Award in the A. James Clark School of Engineering.
- *R&D100 (2022), Expanded Cellulose Super Ion Conductor*. Citation: In pursuit of high-energy and safe batteries, researchers are working to replace the common liquid electrolytes with solid ion conductors. Solid polymer electrolytes are promising candidates but often have limited ionic conductivities of < 10-5 S/cm. This conductivity dilemma has persisted since the solid polymer electrolyte concept was proposed in 1978. The team at the University of Maryland overcame this challenge by inventing a disruptive super ion conductor using expanded cellulose derived from tree wood. This super ion conductor yields a record-high ionic conductivity of 1.5×10−3 S/cm (10–100x- improvement), which is a significant step toward bringing solid-state battery technology to the mass market. This expanded cellulose concept could be a paradigm shifting advance for next-generation batteries. The molecular-expanding strategy also allows for a wide range of applications, such as fuel cells.
- 2021 Nature Spinoff Prize by Nature
- R&D100 (2021), UHS rapid sintering. Citation: The team has invented and patented an ultrafast high-temperature sintering (UHS) process that can achieve record-high temperatures of up to 3,000 ℃ and ultrafast heating rates of up to 100,000 ℃/minute via radiative heating. The UHS method can directly sinter oxide precursors into solid, dense ceramics in just seconds.
- Fellow of MRS, Class of 2021. Citation: For his pioneering advances in the area of wood nanotechnologies and ultra-high temperature manufacturing and for uncovering new materials and methods for energy storage and conversion, printed electronics and wearables.
- 2022 American Chemical Society Energy & Fuels (ENFL) Research Excellence Award in Electrochemical Energy Storage
- 2022 Technical Association of the Pulp and Paper Industry Nano Technical Award
- 2019, 2020, 2021, 2022 Blavatnik National Award for Young Scientists Finalist
- 2021 Distinguished Scholar-Teacher Award
- R&D100 (2020), High Entropy Alloy Catalysts. Citation: Finding new and better catalysts is paramount yet largely limited by immiscibility among elements and slow experimentation. Researchers at the University of Maryland invented a disruptive high-temperature shock technique (e.g., 2000 K within 1 sec) and opened a new material space of multielement high entropy alloy catalysts, which exhibit significantly higher performance and stability than few-element catalysts. The rapid synthesis further enables data-driven, accelerated exploration, and continuous optimization in the unlimited multielement space for various catalytic reactions. This technology was initially reported in Science and further developed as a product in 2019. It has raised significant interests from industry and government agencies (e.g., funding from Maryland Innovation Initiative and Dept. of Energy ARPA-E). High entropy alloy catalysts will become next-generation, game-change catalysts for a wide range of fields, including battery and fuel cells, chemical and drug production.
- 2019 TAPPI Nano Middle Career Award

- R&D100 (2018), Super Wood: Stronger and Lighter Than Steel
- 2017 ACS Nano Letter Young Investigator
- 2016 Emerging Investigator Award, ACS Division of Energy and Fuel
- 2016 ONR Young Investigator Award
- 2013 Air Force Young Investigator Award (AFOSR YIP)

Professional Services:

(a) Editorships:

- Associate Editor, ACS Nano, American Chemical Society, Since January 2023.
- Program Chair, American Chemical Society Energy and Fuels Division, 2024.
- Advisory Panel, Nature Sustainability
- Associate Editor, Energy Storage Materials, 01/2018-12/2021, Impact Factor ~ 15
- International Editorial Advisory Board, Small Structures, Wiley, Since March 2020
- Editorial Advisory Board of Advanced Functional Materials, Since October, 2018
- Committee chair of TAPPI on Electronic Materials, Optical Materials and Catalysis/Templating, 2016-Present
- 2014~present, Editorial Board of Nature Scientific Report
- 2016~2017, Editorial Board of Energy Storage Materials
- Editorial Board of Frontiers in Energy Storage
- Editorial Advisory Board of Advanced Fiber Materials, 2018

(b) Reviewer for:

Science, Nature, Nature Reviews Materials, Nature Materials, Nature Energy, Nature Nanotechnology, Nature Synthesis, Nature Catalysis, Nature Sustainability, Nature Water, Nature Communications, Science Advances, Chemical Society Reviews, Chemical Reviews, Journal of American Chemical Society, Angewandte Chemie International Edition, Proceeding of the National Academy of Sciences, Energy and Environmental Science, Matter, Chem, Joule, Materials Today, Advanced Materials, Advanced Energy Materials, Advanced Functional Materials, ACS Energy Letters, ACS Materials Letter, ACS Nano, ACS Central Science, Nano Letters, Energy Storage Materials, Nano Energy, Chemistry of Materials, Small, Small Methods, ACS Applied Materials Interfaces, Nano Research, Chemical Engineering Journal, Journal of Materials Chemistry A, Chemical Communications, Journal of the Electrochemical Society, Journal of Power Sources, Cell Reports Physical Science, Scientific Reports.

(c) Organizer of Professional Conferences:

- SMART Conference, leading organizer, 2022
- ACS Division of Cellulose and Renewable Materials, Symposium Organizer, Emerging Applications of Bio-Based Nanomaterials, ACS Spring, 2022
- MRS Symposium, Advanced Solid-State Batteries, Seattle, Washington, Spring 2021.
- Workshop Lead-Organizer, NSF Convergence Workshop on Re-think Nature for Innovative Solutions to Grand Challenges, Oct 2020
- Symposium Lead-Organizer, ACS National Meeting, Wood-mimics: Hierarchical Structures and Architectures, Philadelphia, Spring 2018
- MRS Symposium Lead-Organizer, MRS Fall, Solid State Batteries: Materials, Interfaces, and Performance, Boston, 2018.
- Symposium Lead-Organizer, 255th ACS National Meeting, Wood-Based Materials for Energy and Water, New Orleans, Louisiana, 2018
- Symposium Co-Organizer, Two-dimensional Materials for Energy and Fuel, 254th ACS National Meeting, Washington DC, 2017

- 'Manufacturing Science and Technology' Program Committee for the AVS 64th International Symposium & Exhibition, also 63th
- Symposium Lead-Organizer, Cellulose Electronics, TAPPI Nano, 2017 International Conference on Nanotechnology for Renewable Nanomaterials.
- Symposium Lead-Organizer, MRS Fall, Materials science and materials chemistry for grid-scale energy storage, Boston, 2016
- Symposium Lead-Organizer, TAPPI Nano, International Conference on Nanotechnology for Renewable Nanomaterials, 2016, 2017, 2018, 2019, 2020
- Symposium Co-Organizer, 2D Materials: Graphene & Beyond & their Device Applications, 252nd ACS National Meeting, 2016
- Innovative Chemistry & Materials for Electroenergy Production & Storage, 252nd ACS National Meeting, 2016
- Symposium Lead-Organizer, MRS Fall, Nanocellulose Materials and Beyond-Nanoscience, Structures, Devices and Nanomanufacturing, Boston, 2015
- Symposium Lead-Organizer, TAPPI Nano, 2015 International Conference on Nanotechnology for Renewable Nanomaterials, Atlanta, 2015
- Symposium Co-Organizer, Two-dimensional Materials for Energy and Fuel, 249th ACS National Meeting, Denver, Texas-Division of Energy and Fuel, 2015
- Symposium Co-Organizer, Two-dimensional Materials for Energy and Fuel, 247th ACS National Meeting, Dallas, Texas-Division of Energy and Fuel, 2014
- Symposium Lead-Organizer, 3rd International Symposium on Graphene for Energy and Fuels, 248th ACS National Meeting, San Francisco, California-Division of Energy and Fuel, 2014
- Symposium Lead-Organizer, Applications and Manufacturing of Devices on Paper and Textiles, 61th AVS National Meeting, Baltimore, Maryland, 2014
- Symposium Co-Organizer, ISDRS 2013 International Semiconductor Device Research, Hyatt Regency Bethesda, Maryland, 2013
- Symposium Lead-Organizer, Materials Challenges and Integration Strategies for Flexible Energy Devices and Systems, MRS Spring, San Francisco, 2014
- Symposium Co-Organizer, Capacitors and Related Systems for Energy Storage, 245th ACS National Meeting, New Orleans-Division of Energy and Fuel, 2013
- Symposium Co-Organizer, 2nd International Symposium on Graphene for Energy and Fuels, Indianapolis, Indiana, 2013

Publications:

(a) Peer Reviewed Journal Articles (Total 461 Publications in Five Research Areas)

Research Area 1. Wood and Nanocellulose for Emerging Technologies (Total 166 Publications)

166. Jing, S.; Wu, L.; Siciliano, A.; Chen, C.; Li, T.; **Hu, L***. The Critical Roles of Water in the Processing, Structure, and Properties of Nanocellulose, **ACS Nano**, 2023.

165. Meng, T.; Ding, Y.; Liu, Y.; Xu L.; Mao, Y.; Gelfond, J.; Li, S.; Li, Z.; Salipante, P.; Kim, H.; Zhu, J.; Pan, X*.; **Hu, L***. In Situ Lignin Adhesion for High-Performance Bamboo Composites, **Nano letters**, 2023.

164. Chen, X.; Yang, M.; Zheng, S.; Temprano-Coleto, F.; Dong, Q.; Cheng, G.; Yao, N.; Stone, H.; **Hu, L.**; Ren, Z.; Spatially Separated Crystallization for Selective Lithium Extraction from Saline Water, **Nature Water**, 2023, accepted.

163. He, S.; Zhao, X.; Wang, E.; Chen, G.; Che, P.; **Hu, L*** Engineering Wood: Sustainable Technologies and Applications, **Annual Review of Materials Research**, 2023, accepted.

162. Gelfond, J.; Meng, T.; Li, S.; Li, T.; **Hu, L**[*] Highly electrically conductive biomass-derived carbon fibers for permanent carbon sequestration, **Sustainable Materials and Technologies**, 2023, e00573.

161. Chen, C.; Zhou, Y.; Xie, W.; Meng, T.; Zhao, X.; Pang, Z.; Chen, Q.; Liu, D.; Wang, R.; Yang, V.; Zhang, H.; Xie, H.; Leiste, U.; Fourney, W.; He, S.; Cai, Z.; Ma, Z.; Li, T.; Hu, **Hu, L**[*] Lightweight, Thermally Insulating, Fire-Proof Graphite-Cellulose Foam, **Advanced Functional Materials**, 2022, 33, 2204219.

160. Zhao, X.; Liu, Y.; Zhao, L.; Yazdkhasti A.; Mao, Y.; Siciliano, A.; Dai, J.; Jing, S.; Xie, H.; Li, Z.; He, S.; Clifford, B.; Li, J.; Che, G.; Wang, E.; Desjarlais, A.; Saloni, D.; Yu, M.; Kosny, J. Zhu, Y. Gong, A.; **Hu, L**[*] A Scalable, High-Porosity Wood for Sound Absorption and Thermal Insulation, **Nature Sustainability**, 2023, 1-10.

159. Qian, J.; Dong, Q.; Chun, K.; Zhu, D.; Zhang, X.; Mao, Y.; Culver, J. Tai, S.; German, J.; Dan, D.; Miller, J. Wang, L. Wu, T.; Li, T.; Brozena, A.; Briber, R.; Milton, D.; Bentleu, W.; **Hu, L**[*] Highly Stable, Antiviral, Antibacterial Cotton Textiles via Molecular Engineering, **Nature Nanotechnology**, 2022, 1-9.

158. Yu, S.; Liu, Y.; Chen, C.; Feng, S.; Siciliano, A.P.; **Hu, L**[*]. Liu, P. A low-corrosivity structural timber. **Cell Reports Physical Science**, 2022, 3, 100921.

157. Qi, J.; Chen, Q.; Hong, M.; Xie, W.; Jing, S.; Bao, Y.; Chen, G.; Pang, Z.; **Hu, L**[*]; Li, T. Toward stretchable batteries: 3D-printed deformable electrodes and separator enabled by nanocellulose, **Materials Today**, 2022, 54, 18.

156. Wu, M.; Zhang, X.; Zhao, Y.; Yang, C.; Jing, S.; Wu, Q.; Brozena, A.; Miller, J.; Libretto, N.; Wu, T.; Bhattacharyya, S.; Garaga, M.; Zhang, Y.; Qi, Y.; Greenbaum, S.; Briber, R.; Yang, Y. **Hu, L**[*]. A high-performance hydroxide exchange membrane enabled by Cu^{2+}-crosslinked chitosan. **Nature Nanotechnology**, 2022, 17, 629. (**Article, COVER Finalist**).

155. Eichhorn, S.; Etale, A.; Wang, J.; Berglund, L.A.; Li, Y.; Cai. Y.; Chen, C.; Cranston, E.D.; Johns, M.; Fang, Z.; Li, G.; **Hu, L.**; Khandelwal, M.; Lee, K.-Y.; Oksman, K.; Pinitsoontorn, S.; Quero, F.; Sebastian, A.; Titirici, M; Xu, Z; Vignolini, S; Frka-Petesic, B; Current International Research into Cellulose as a Functional Nanomaterial for Advanced Applications, **Journal of Materials Science**, 2022, 57, 5697.

154. Li, Z.; Chen, C.; Xie, H.; Yao, Y.; Zhang, X.; Brozena, A.; Li, J.; Ding, Y.; Zhao, X.; Hong, M; Qiao, H.; Smith, L.M.; Pan, X.; Briber, R.; Shi, S.; **Hu, L**[*]. Sustainable High-Strength Macrofibres Extracted from Natural Bamboo, **Nature Sustainability**, 2022, 5, 235.

153. Xiao, S.; Chen, C.; Xia, Q.; Liu, Y.; Yao, Y.; Chen, Q.; Hartsfield, M; Brozena, A.; Tu, K.; Eichhorn, S.J.; Yao, Y.; Li, J.; Gan, W.; Shi, S.; Yang, V.; Ricco, M.; Zhu, J.; Burgert, I.; Luo, A.; Li, T.; **Hu, L**[*]. Lightwight, Strong, Moldable Wood via Cell Wall Engineering as a Sustainable Structural Material, **Science**, 2021, 374, 465. (**Cover**)

152. Chen, G.; Li, T.; Chen, C.; Kong, W.; Jiao, M; Jiang, B.; Xia, Q.; Liang, Z.; Liu, Y.; He, S.; **Hu, L**[*]. Scalable Wood Hydrogel Membrane with Nanoscale Channels, **ACS Nano**, 2021, 15, 11244.

151. Chen, X.; He, S.; Falinski, M; Wang, Y.; Li, T.; Zheng, S.; Sun, D.; Dai, J.; Bian, Y.; Zhu, X.; Jiang, J.; **Hu, L**.[*]; Ren, Z. Sustainable off-grid desalination of hypersaline waters using Janus wood evaporators, **Energy & Environmental Science**, 2021, 14, 5347.

150. Kong, W.; Chen, C.; Chen, G.; Wang, C.; Liu, D.; Das, S.; Chen, G.; Li, T.; Li, J.; Liu, Y.; Li, Z.; Clifford, B.; **Hu, L**[*]. Wood Ionic Cable, **Small**, 2021, 17, 2008200.

149. Zhao, X.; Brozena, A.H.; **Hu, L**[*]. Critical Roles of Pores and Moisture in Sustainable Nanocellulose-Based Super-Thermal Insulators, **Matter**, 2021, 4, 769.

148. Liu, D.; Chen, C.; Zhou, Y.; Bao, Y.; Wang, R.; Liu, Y.; He, S.; Huang, H.; Zhang, C.; Foster, B.; Li, T.; **Hu, L.**[*] 3D-Printed, High-Porosity, High-Strength Graphite Aerogel, **Small Methods**, 2021, 5, 2001188.

147. Xia, Q.; Chen, C.; Yao, Y.; Li, J.; He, S.; Zhou, Y.; Li, T.; Pan, X.; Yao, Y.; **Hu, L**[*]. A Strong, Biodegradable and Recyclable Lignocellulosic Bioplastic, **Nature Sustainability**, 2021, 4, 627.

146. Li, J.; Chen, C.; Gan, W.; Li, Z.; Xie, H.; Jiao, M.; Xiao, S.; Tang, H.; **Hu, L.**[*] A Bio-Inspired, Hierarchically Porous Structure with Decoupled Fluidic Transportation and Evaporative Pathway toward High-Performance Evaporation, **Journal of Materials Chemistry A**, 2021, 9, 9745.

145. Wang, X.; Xia, Q.; Jing, S.; Li, C.; Chen, Q.; Chen, B.; Pang, Z.; Jiang, B.; Gan, W.; Chen, G.; Cui, M.; **Hu, L.**[*]; Li, T.[*] Strong, Hydrostable, and Degradable Straws Based on Cellulose-Lignin Reinforced Composites, **Small**, 2021, 17, 2008011.

144. Lamm, M. E.; Li, K.; Qian, J.; Wang, L.; Lavoine, N.; Newman, R.; Gardner, D. J.; Li, T.; **Hu, L.**; Ragauskas, A. J.; Tekinalp, H.; Kunc, V.; Ozcan, S. Recent Advances in Functional Materials Through Cellulose Nanofiber Templating, **Advanced Materials**, 2021, 33, 2005538.

143. Li, K.; Clarkson, C.; Wang, L.; Liu, Y.; Lamm, M.; Pang, Z.; Zhou, Y.; Qian, J.; Tajvidi, M.; Gardner, D.; Tekinalp, H.; **Hu, L.**[*]; Li, T.; Ragauskas, A.; Youngblood, J.; Ozcan, S. The Alignment of Cellulose Nanofibers: Harnessing Nanoscale Properties to Macroscale Benefits, **ACS Nano**, 2020, 15, 3646.

142. Xia, Q.; Chen, C.; Li, T.; He, S.; Gao, J.; Wang, X.; **Hu, L.**[*] Solar-Assisted Fabrication of Large-Scale, Patternable Transparent Wood, **Science Advances**, 2020, 7, eabd7342.

141. Li, T.; Chen, C.; Brozena, A.; Zhu, J.; Xu, L.; Driemeier, C.; Dai, J.; Rojas, O.; Isogai A.; Wagberg, L.; **Hu, L.**[*] Developing Fibrillated Cellulose as a Sustainable Technological Material, **Nature**, 2021, 590, 47.

140. Chen, C.; Berglund, L.; Ingo, B.; **Hu, L.**[*] Wood Nanomaterials and Nanotechnologies, **Advanced Materials,** 2021, 33, 2006207. (**Guest Editorial**)

139. Chen, C.; Song, J.; Cheng, J.; Pang, Z.; Gan, W.; Chen, G.; Kuang, Y.; Huang, H.; Ray, U.; Li, T.; **Hu, L.**[*] Highly Elastic Hydrated Cellulosic Materials with Durable Compressibility and Tunable Conductivity. **ACS Nano**, 2020, 1, 16723.

138. Xia, Q.; Chen, C.; **Hu, L.**[*] In situ Lignin Modification Toward Photonic Wood. **Advanced Materials**, 2021, 33, 2001588.

137. Mi, R.; Chen, C.; Keplinger, T.; Pei, Y.; He, S.; Liu, D.; Li, J.; Dai, J.; Hitz, E.; Yang, B.; Burgert, I.; **Hu, L.**[*] Scalable Aesthetic Transparent Wood for Energy Efficient Building, **Nature Communications**, 2020, 11, 1.

136. Jiang, B.; Yao, Y.; Liang, Z.; Gao, J.; Chen, G.; Xia, Q.; Mi, R.; Jiao, M.; Wang, X.; **Hu, L.**[*] Lignin-Based Direct Ink Printed Structural Scaffolds, **Small**, 2020, 16, 1907212.

135. Gan, W.; Chen, C.; Giroux, M.; Zhong, G.; Goyal, M.; Wang, Y.; Ping, W.; Song, J.; Xu, S.; He, S.; Jiao, M.; Wang, C.; **Hu, L.**[*] Conductive Wood for High-Performance Structural Electromagnetic Interference Shielding, **Chemistry of Materials**, 2020, 32, 5280.

134. Chen, X.; Zhu, X.; He, S.; Hu, L. Ren, Z. Advanced Nanowood Materials for Water Energy Nexus, **Advanced Materials**, 2021, 33, 2001240.

133. Chen, C.; **Hu, L.**[*] Nanoscale Ion Regulation in Wood-Based Structures and Their Device Applications. **Advanced Materials**,2021, 33, 2002890. (**Back cover**)

132. Chen, C.; Li, Z.; Mi, R.; Dai, J.' Xie, H.' Pei, Y.; Li, J.; Qiao, H.; Tang, H.; Yang, B.; **Hu, L.**[*] Rapid Processing of Whole Bamboo with Exposed, Aligned Nanofibrils Toward a High-Performance Structural Material, **ACS Nano**, 2020, 14, 5194.

131. Jiao, M.; Yao, Y.; Chen, C.; Jiang, B.; Pastel, G.; Lin, Z.; Wu, Q.; Cui, M.; He, S.; **Hu, L**.* Highly Efficient Water Treatment via a Wood-based and Reusable Filter, **ACS Materials Letters**, 2020, 2, 430.

130. Li, Y.; Chen, C.; Song, J.; Yang, C.; Kuang, Y.; Vellore, A.; Hitz, E.; Zhu, M.; Jiang, F.; Yao, Y.; Gong, A.; Martini, A.; **Hu, L.*** Strong and Superhydrophobic Wood with Aligned Cellulose Nanofibers as a Waterproof Structural Material, **Chinese Journal of Chemistry,** 2020, 38, 823.

129. Wang, X.; Pang, Z.; Chen, C.; Xia, Q.; Zhou, Y.; Jing, S.; Wang, R.; Ray U.; Gan, W.; Chen, G.; Foster, B.; Li, T.; **Hu, L. ***, All Natural, Degradable, Rolled-up Straws Based on Cellulose Micro- and Nano- Hybrid Fibers, **Advanced Functional Materials**, 2020, 30, 1910417.

128. Jiao, M.; Liu, T. *****; Chen, C.; Yue, M.; Pastel, G.; Yao, Y.; Xie, H.; Gan, W.; Gong, A.; Li, X.; **Hu, L.***, Holey Three-Dimensional Wood-based Electrode for Vanadium Flow Batteries, **Energy Storage Materials**, 2020, 27, 327.

127. Chen, C.; Kuang, Y.; Zhu, S.; Burgert, I.; Keplinger, T.; Gong, A.; Li, T.; Berglund, L.; Eichhorn, S.; **Hu, L.*** Structure-Property-Function Relationships of Natural and Engineered Wood, **Nature Reviews Materials**, 2020, 5, 642.

126. He, S.; Chen, C.; Chen, G.; Chen, F.; Dai, J.; Song, J.; Jiang, F.; Jia, C.; Xie, H.; Yao, Y.; Hitz, E.; Chen, G.; Mi, R.; Jiao, M.; Das, S.; **Hu, L.*** , A High-Performance, Scalable Wood-based Filtration Device with a Reversed-Tree Design, **Chemistry of Materials**, 2020. 32, 1887.

125. Gan, W.; Chen, C.; Wang, Z.; Pei, Y.; Ping, W.; Xiao, S.; Dai, J.; Yao, Y.; He, S.; Zhao, B.; Das, S.; Yang, B.; Sunderland, P.; **Hu, L.***, Fire-Resistant Structural Material Enabled by an Anisotropic Thermally Conductive Hexagonal Boron Nitride Coating, **Advanced Functional Materials**, 2020, 30, 1909196.

124. He, S.; Chen, C.; Li, T.; Song, J.; Zhao, X.; Kuang, Y.; Liu, Y.; Pei, Y.; Hitz, E.; Kong, W.; Gan, W.; Yang, B.; Yang, R.; **Hu, L.***, An Energy-Efficient, Wood-Derived Structural Material Enabled by Pore Structure Engineering Towards Building Efficiency, **Small Methods**, 2020, 4, 1900747.

123. Li, Z.; Chen, C.; Mi, R.; Gan, W.; Dai, J.; Jiao, M.; Xie, H.; Yao, Y.; Xiao, S.; **Hu, L.***, A Strong, Tough, and Scalable Structural Material from Fast-Growing Bamboo, **Advanced Materials**, 2020, 32, 1906308.

122. Wu, Q.; Wang, C.; Wang, R.; Chen, C.; Gao, J.; Dai, J.; Liu, D.; Lin, Z.; **Hu, L.***, Salinity-Gradient Power Generation with Ionized Wood Membranes, **Advanced Energy Materials**, 2020, 10, 1902590.

121. Mi, R.; Li, T.; Dalgo, D.; Zhao, X.; Kuang, Y.; He, S.; Liu, D.; Gan, W.; Gong, A.; Srebric, J.; Yang, R.; **Hu, L.***, A Clear, Strong, and Thermally-Insulated Transparent Wood for Energy Efficient Windows, **Advanced Functional Materials**, 2020, 30, 1907511.

120. Zhao, D.; Zhu, Y.; Chen, W.; Xu, G.; Wang, Q.; Liu, S.; Li, J.; Chen, C. *****; Yu, H. *****; **Hu, L. *,** A Dynamic Gel with Reversible and Tunable Topologic Networks and Performances, **Matter**, 2020, 2, 390.

119. Chen, G.; Chen, C.; Pei, Y.; He, S.; Liu, Y.; Jiang, B.; Jiao, M.; Gan, W.; Liu, D.; Yang, B.; **Hu, L.***, A Strong, Flame-retardant, and Thermally Insulating Wood Laminate. **Chemical Engineering Journal**, 2020, 383, 123109.

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Patents and Patent Applications:

Issued Patents (Total 25)

25. Graphene Film as Transparent and Electrically Conducting Material

U.S. Patent No. 7,449,133
Inventors: George Gruner, Liangbing Hu, David Hecht

24. Method of Producing a Graphene Film as Transparent and Electrically Conducting Material
U.S. Patent No. 7,785,557
Inventors: George Gruner, David Hecht, Liangbing Hu

23. Touch Screen Devices Employing Nanostructure Networks
U.S. Patent No. 8,390,589
Inventors: Liangbing Hu, George Gruner

22. Transparent and Conductive Nanostructure-film Pixel Electrode and Method of Making the Same
U.S. Patent No. 8,785,939
Inventors: Young-bae Park, George Gruner, Liangbing Hu

21. Compliant and Nonplanar Nanostructure Films
U.S. Patent No. 8,815,346
Inventors: Liangbing Hu, David Hecht, Jeffrey Jue, George Gruner

20. Electrodes with Electrospun Fibers
U.S. Patent No. 8,940,194
Inventors: Yi Cui, Hui Wu, Liangbing Hu

19. Transparent Electrochemical Energy Storage Devices
U.S. Patent No. 8,956,757
Inventors: Yuan Yang, Liangbing Hu, Yi Cui, Sangmoo Jeong

18. Nanotube-based Nanomaterial Membrane
U.S. Patent No. 8,974,967
Inventors: Li-Feng Cui, Yi Cui, Liangbing Hu

17. Method for Forming a Nano-textured Substrate
U.S. Patent No. 8,999,857
Inventors: Sangmoo Jeong, Liangbing Hu, Yi Cui

16. Conductive Fibrous Materials
U.S. Patent No. 9,138,965
Inventors: Liangbing Hu, Jang Wook Choi, Yuan Yang, Yi Cui

15. Transparent Hybrid Substrates, Devices Employing such Substrates, and Methods for Fabrication and Use Thereof
U.S. Patent No. 10,411,222
Inventors: Liangbing Hu, Yonggang Yao, Tian Li

14. Super Clear Cellulose Paper
U.S. Patent No. 10,480,126
Inventors: Liangbing Hu,Zhiqiang Fang, Hongli Zhu

13. Ion Conducting Batteries with Solid State Electrolyte Materials
U.S. Patent No. 10,622,666
Inventors: Eric D. Wachsman, Liangbing Hu, Venkataraman Thangadurai

12. Protection Layers for Metal Anodes
U.S. Patent No. 10,826,065
Inventors: Alexander C. Kozen, Marshall A. Schroeder, Gary W. Rubloff, Liangbing Hu, Malakhi Noked, Sang Bok Lee

11. Membranes and Methods of Use Thereof
U.S. Patent No. 10,940,444
Inventors: Liangbing Hu, Fengjuan Chen, Amy Gong

10. Interfacial Layers for Solid-state Batteries and Methods of Making Same
U.S. Patent No. 10,971,761
Inventors: Liangbing Hu, Xiaogang Han, Eric D. Wachsman, Yifei Mo

9. Scalable, Highly Transparent Paper with Microsized Fiber
U.S. Patent No. 10,982,390
Inventors: Liangbing Hu, Zhiqiang Fang, Hongli Zhu

8. Metal Alloy Layers on Substrates, Methods of Making Same, and Uses Thereof
U.S. Patent No. 11,043,696
Inventors: Liangbing Hu, Eric D. Wachsman, Yunhui Gong, Kun Fu, Wei Luo, Chengwei Wang

7. Strong and Tough Structural Wood Materials, and Methods for Fabricating and Use Thereof
U.S. Patent No. 11,130,256
Inventors: Liangbing Hu, Mingwei Zhu, Jianwei Song

6. Thermal Shock Synthesis of Multielement Nanoparticles
U.S. Patent No. 11,193,191
Inventors: Yonggang Yao, Liangbing Hu

5. Nanoparticles and Systems and Methods for Synthesizing Nanoparticles Through Thermal Shock
U.S. Patent No. 11,369,929
Inventors: Liangbing Hu, Yanan Chen, Yonggang Yao

4. Ion-conducting Structures, Devices including Ion-conducting Structures, and Methods for Use and Fabrication Thereof
U.S. Patent No. 11,374,255
Inventors: Liangbing Hu, Tian Li, Chunpeng Yang, Xin Zhang, Robert M. Briber, MeiLing Wu

3. Wood-based Solar Thermal Devices, and Methods for Fabrication and Use Thereof
U.S. Patent No. 11,578,894
Inventors: Liangbing Hu, Mingwei Zhu, Yiju Li, Chaoji Chen, Tian Li, He Liu, Amy Gong, Yudi Kuang

2. Lithium Battery
U.S. Patent No. 11,569,527
Inventors: Liangbing Hu, Eric D. Wachsman, Boyang Liu, Lei Zhang, Shaomao Xu, Dennis McOwen, Chunpeng Yang

1. Inverted Battery Devices, and Systems and Methods for Use Thereof
U.S. Patent No. 11,724,024
Inventors: Liangbing Hu, Chengwei Wang

Patent Applications (Total 45)

45. Transparent Wood Composite, Systems and Method of Fabrication
U.S. Application No. 16/074,148
Filing date: 7/31/18
Inventors: Liangbing Hu, Mingwei Zhu, Tian Li, Amy Gong, Jianwei Song

44. Lithium Solid State Electrolyte Interface Treatment
U.S. Application No. 16/345,826
Filing date: 4/29/19
Inventors: Liangbing Hu, Eric Wachsman, Chengwei Wang, Yunhui Gong

43. Rapid Thermal Annealing of Cathode-electrolyte Interface for High-temperature Solid-state Batteries
U.S. Application No. 16/514,994
Filing date: 7/17/19
Inventors: Liangbing Hu, Boyang Liu, Kun Fu, Chengwei Wang

42. Solid-state Hybrid Electrolytes, Methods of Making Same, and Uses Thereof
U.S. Application No. 16/499,203
Filing date: 9/27/19
Inventors: Liangbing Hu, Eric D. Wachsman, Boyang Liu, Yunhui Gong, Kun Fu

41. Flexible Wood Structures and Devices, and Methods for Fabricating and Use Thereof
U.S. Application No. 16/500,745
Filing date: 10/3/19
Inventors: Liangbing Hu, Jianwei Song, Chaoji Chen, Amy Gong

40. Delignified Wood Materials, and Methods for Fabricating and Use Thereof
U.S. Application No. 16/647,154
Filing date: 3/13/20
Inventors: Liangbing Hu, Tian Li, Shuaiming He, Jianwei Song, Chaoji Chen

39. Ion Conducting Batteries with Solid State Electrolyte Materials
U.S. Application No. 16/847,582
Filing date: 4/13/20
Inventors: Eric D. Wachsman, Liangbing Hu, Venkataraman Thangadurai, Gregory Thomas Hitz, Dennis McOwen

38. Composite Electrodes and Manufacture Thereof
U.S. Application No. 16/850,997
Filing date: 4/16/20
Inventors: Liangbing Hu, Dylan Kirsch, Steven Lacey, Yi Lin, John W. Connell

37. Solid State Battery System Usable at High Temperatures and Methods of Use and Manufacture Thereof
U.S. Application No. 16/882,536
Filing date: 5/24/20
Inventors: Liangbing Hu, Chengwei Wang, Eric D. Wachsman, Venkataraman Thangadurai

36. Graphite Materials, and Methods for Fabricating and Use Thereof
U.S. Application No. 16/967,165

Filing date: 8/4/20
Inventors: Liangbing Hu, Yubing Zhou, Chaoji Chen, Teng Li, Robert W. Foster, Dapeng Liu

35. Solid-State Li-S Batteries and Methods of Making Same
U.S. Application No. 17/184,500
Filing date: 2/24/21
Inventors: Eric D. Wachsman, Liangbing Hu, Chunsheng Wang, Yang Wen, Kun Fu, Fudong Han, Chengwei Wang, Venkataraman Thangadurai, Gregory Thomas Hitz, Dennis McOwen

34. High-temperature Shock Heating for Thermochemical Reactions
U.S. Application No. PCT/US2021/022204
Filing date: 3/12/21
Inventors: Liangbing Hu, Dongxia Liu, Qi Dong, Yonggang Yao

33. Scalable, Highly Transparent Paper with Microsized Fiber
U.S. Application No. 17/210,849
Filing date: 3/24/21
Inventors: Liangbing Hu, Zhiqiang Fang, Hongli Zhu

32. Extraction of Delignified, Cellulose-based Fibers from Natural Plant Material, and Materials Incorporating such Fibers
U.S. Application No. PCT/US2021/028333
Filing date: 4/21/21
Inventors: Liangbing Hu, Chaoji Chen, Zhihan Li, Jianguo Li

31. Evaporative Devices Having Delignified Plant Materials, and Systems and Methods for Fabrication and Use Thereof
U.S. Application No. PCT/US2021/028318
Filing date: 4/21/21
Inventors: Liangbing Hu, Chaoji Chen, Zhihan Li, Jianguo Li

30. Moldable and Molded Cellulose-based Structural Materials, and Systems and Methods for Forming and Use Thereof
U.S. Application No. PCT/US2021/028541
Filing date: 4/22/21
Inventors: Liangbing Hu, Shaoliang Xiao, Chaoji Chen, Yu Liu

29. Modified Wood and Transparent Wood Composites, and Systems and Methods for Forming and Use Thereof
U.S. Application No. PCT/US2021/041181
Filing date: 7/9/21
Inventors: Liangbing Hu, Ruiyu Mi, Qinqin Xia, Chaoji Chen, Tian Li

28. Rapid Sintering of Metal Coatings for Pipe Repair
U.S. Application No. 63/229,848
Filing date: 8/5/21
Inventors: Liangbing Hu, Qi Dong, Paul Albertus

27. Strong and Tough Structural Wood Materials, and Methods for Fabricating and Use Thereof
U.S. Application No. 17/408,695
Filing date: 8/23/21

Inventors: Liangbing Hu, Mingwei Zhu, Jianwei Song

26. Waste-free Processing for Lignin Modification of Fibrous Plant Materials, and Lignin-modified Fibrous Plant Materials
U.S. Application No. 63/237,625
Filing date: 8/27/21
Inventors: Liangbing Hu, Yu Liu

25. High-entropy Alloy (HEA) Catalysts, Methods of Forming HEA Catalysts, and Methods of Using HEA Catalysts
U.S. Application No. 17/466,781
Filing date: 9/3/21
Inventors: Chao Wang, Liangbing Hu

24. Lignocellulosic Bioplastics and Composites, and Methods for Forming and Use Thereof
U.S. Application No. PCT/US2021/050575
Filing date: 9/16/21
Inventors: Liangbing Hu, Chaoji Chen, Qinqin Xia

23. Supported Multielement Nanoparticle Catalyst and Methods of Making and Using the Same
U.S. Application No. 63/261,557
Filing date: 9/23/21
Inventors: Liangbing Hu, Tangyuan Li, Chao Wang, Yunhui Gong

22. Solid-state Electrolyte Materials with Volatile Sintering Aids and Methods of Making and Using the Same
U.S. Application No. 63/261,947
Filing date: 9/30/21
Inventors: Liangbing Hu, Qi Dong

21. Tantalum/Titanium Oxide Nanoparticles as Radical Scavengers for Durable Platinum-Group-Metal Free Oxygen Reduction Catalysts
U.S. Application No. 63/262,061
Filing date: 10/4/21
Inventors: Liangbing Hu, Hua Xie, Yuyan Shao

20. High Temperature, Pulsed Heating Reactor and Methods for Polymer Recycling
U.S. Application No. 63/262,088
Filing date: 10/4/21
Inventors: Liangbing Hu, Qi Dong

19. Systems and Methods for High Temperature Synthesis of Single Atom Dispersions and Multi-atom Dispersions
U.S. Application No. 17/618,959
Filing date: 12/14/21
Inventors: Liangbing Hu, Yonggang Yao

18. Multi-element Compound Nanoparticles, and Systems and Methods of Making and Use Thereof
U.S. Application No. PCT/US2021/063487
Filing date: 12/15/21
Inventors: Liangbing Hu, Yonggang Yao, Tangyuan Li, Mingjin Cui, Jinlong Gao

17. High-performance Multilayer Structure Solid-state Electrolytes by Ultrahigh Temperature Sintering and their Battery Use
U.S. Application No. 63/265,857
Filing date: 12/22/21
Inventors: Liangbing Hu, Chengwei Wang

16. Metal Nanodisks via High Temperature Vapor to Crystal Deposition
U.S. Application No. 63/265,859
Filing date: 12/22/21
Inventors: Liangbing Hu, Xizheng Wang

15. Systems and Methods for Combinatorial Synthesis and Screening of Multielement Materials
U.S. Application No. 17/690,767
Filing date: 3/9/22
Inventors: Liangbing Hu, Yonggang Yao

14. Metallic Glass Nanoparticles and Methods of Making the Same
U.S. Application No. PCT/US22/21372
Filing date: 3/22/22
Inventors: Liangbing Hu, Yonggang Yao

13. High Temperature Sintering Furnace System
U.S. Application No. PCT/US22/21915
Filing date: 3/25/22
Inventors: Liangbing Hu, Xinpeng Zhao

12. Bamboo Structures, and Methods for Fabrication and Use Thereof
U.S. Application No. 17/778,690
Filing date: 5/20/22
Inventors: Liangbing Hu, Chaoji Chen, Zhihan Li

11. Nanoparticles and Systems and Methods for Synthesizing Nanoparticles Through Thermal Shock
U.S. Application No. 17/750,577
Filing date: 5/23/22
Inventors: Liangbing Hu

10. Systems, Methods, and Devices for Carbon Material Upgrade and Organic Compound Pyrolysis
U.S. Application No. PCT/US22/30555
Filing date: 5/23/22
Inventors: Liangbing Hu, Qi Dong

9. Wood Materials Having Anisotropic Elasticity, and Methods for Fabrication and Use Thereof
U.S. Application No. PCT/US2022/031289
Filing date: 05/27/22
Inventors: Liangbing Hu, Xinpeng Zhao, Yu Liu

8. Waste-free Processing for Lignin Modification of Fibrous Plant Materials, and Lignin-modified Fibrous Plant Materials
U.S. Application No. PCT/US2022/041779
Filing date: 08/27/22

Inventors: Liangbing Hu, Yu Liu

7. Catalytic Structures with Metal Oxide Substrates, and Methods for Fabrication and Use Thereof
U.S. Application No. PCT/US2022/044541
Filing date: 09/23/22
Inventors: Liangbing Hu, Tangyuan Li, Robert Gatte, Chao Wang, Noah Zecher-freeman

6. Solid-State Structures with Volatile Sintering Aids, and Methods for Fabrication and Use Thereof
U.S. Application No. PCT/US2022/045326
Filing date: 10/04/22
Inventors: Liangbing Hu, Qi Dong, Min Hong

5. Radical Scavengers, Catalytic Structures with Radical Scavengers, and Methods for Fabrication and Use Thereof
U.S. Application No. PCT/US2022/045611
Filing date: 10/04/22
Inventors: Liangbing Hu, Hua Xie, Yuyan Shao, Venkateshkumar Prabhakaran

4. Polymer Processing Systems and Methods Employing Pulsed Heating
U.S. Application No. PCT/US2022/045656
Filing date: 10/04/22
Inventors: Liangbing Hu, Dongxia Liu, Qi Dong, Sichao Cheng, Yiguang Ju

3. Systems, devices, and methods for in situ pipe repair
U.S. Application No. US17/991,323
Filing date: 11/21/22
Inventors: Liangbing Hu, Paul Albertus, Qi Dong, Chengwei Wang, Edward Petit de Mange

2. Composite Solid-state Electrolytes, Devices with Composite Solid-state electrolytes, and Methods for Fabrication Thereof
U.S. Application No. PCT/US2022/053768
Filing date: 12/22/22
Inventors: Liangbing Hu, Weiwei Ping, Qi Dong, Min Hong

1. Vapor Deposition Systems and Methods, and Nanomaterials Formed by Vapor Deposition
U.S. Application No. PCT/US2022/053771
Filing date: 12/22/22
Inventors: Liangbing Hu, Xizheng Wang