The 5th International Forum on Manufacturing Paradigm III (5th FMP3): Roundtable Discussion

Draft News Release

From 22 to 25 May 2026, the 5th International Forum on Manufacturing Paradigm III (5th FMP3), organized by the International Society for Nanomanufacturing (ISNM) and hosted by the State Key Laboratory of Ultra-precision Machining Technology at The Hong Kong Polytechnic University, was held in Hong Kong, bringing together more than 160 experts and scholars from different countries and regions. Participants agreed that Manufacturing Paradigm III is not simply about further improving machining accuracy, rather it takes the controllable removal, migration, and addition of matter at atomic and close-to-atomic scales as the core foundation for realizing future functional products. Its engineering implementation must advance measurement, efficiency, scalability, artificial intelligence, standards, and international collaboration in parallel.

From 22 to 25 May 2026, the 5th International Forum on Manufacturing Paradigm III (5th FMP3), organized by the International Society for Nanomanufacturing (ISNM) and hosted by the State Key Laboratory of Ultra-precision Machining Technology at The Hong Kong Polytechnic University, was held at The Hong Kong Polytechnic University. The forum focused on frontier topics including Atomic and Close-to-Atomic Scale Manufacturing (ACSM), ultra-precision machining and measurement, digital twins, artificial intelligence, and the integration of advanced manufacturing applications.

Unlike a conventional technical conference, the FMP3 Forum has continued to raise a more fundamental question: when manufacturing technology advances to atomic and close-to-atomic scales, how will its objects, theories, methods, standards, and industries change? Participants generally agreed that Manufacturing Paradigm III is the key to answering this question. It provides a common research framework that connects fundamental theories, key processes, advanced instrumentation, intelligent systems, and important applications.

From “Smaller Scales” to “Basic Units”: The Scientific Connotation of Manufacturing Paradigm III

Conference presentations and roundtable discussions offered an in-depth examination of Manufacturing Paradigm III. Experts noted that its core lies in directing manufacturing objectives and processes toward atoms, and in controlling material removal, migration, and addition at or near the atomic scale so as to integrate the entire process from atoms to final products. This change is not merely a continued improvement in manufacturing accuracy. It signifies a shift in the basic unit of manufacturing action, requiring manufacturing mechanisms to be explained increasingly through interatomic interactions, quantum effects, and atomic-scale material behaviours.

During the roundtable discussions, many experts observed that precision manufacturing and ultra-precision manufacturing have historically evaluated products mainly through geometric indicators such as size, form, and surface quality. In Manufacturing Paradigm III, however, researchers must pay greater attention to the integrity of specific atomic layers, particular atomic arrangements, and atomic interface states. Atoms or atomic layers may directly determine the function and performance of a device. The absence or alteration of a small number of critical atoms may cause abrupt changes in performance. Accordingly, manufacturing evaluation will need to expand from the control of continuous geometric errors to the coordinated characterization of discrete structures, interface states, and functional determinacy.

On the definition of atomic-scale manufacturing, the participants argued that the early stage of this emerging field should remain conceptually open and inclusive, while gradually forming operable technical boundaries. On the one hand, "manufacturing" should be clearly oriented toward products or systems with defined functions, rather than judged only by whether atoms are involved. On the other hand, definitions, standards, and evaluation systems should be built from multiple dimensions, including the processing object, action mechanism, controllability, verifiability, and functional output.

Regarding conceptual boundaries, Jun LI of Nanjing University of Aeronautics and Astronautics proposed that the mere involvement of atoms is not sufficient to define manufacturing. Manufacturing must ultimately point to usable products or functional carriers that can enter an industrial system. Honggang ZHANG of Beijing University of Technology argued that atomic-scale manufacturing cannot simply follow the dimensional progression from millimetres to micrometres to nanometres. Because it deals with the basic units of matter, the meanings of scale, precision, and manufacturing must be clarified, and a standardized definition should gradually be established. Min LAI of Tianjin University noted that Manufacturing Paradigm III shifts research objects from geometric dimensions to atomic layers, atomic lines, and individual atoms, thereby integrating manufacturing-related studies in physics, chemistry, and materials science into a broader concept of manufacturing oriented toward functional products.

Jining SUN of Dalian University of Technology further pointed out that explaining a machining process using atomic mechanisms is not the same as actively changing atomic structures to generate macroscopic functions. The significance of atomic-scale manufacturing is truly established only when controllable changes at the atomic level become a necessary pathway for realizing product functions. Yang HE of University

College Dublin emphasized, from the perspective of experimental processes, that atomic-scale machining should consider not only the removed or added parts, but also the structures ultimately retained. More critically, probabilistic atomic migration, addition, or removal must be transformed into stable, repeatable, and deterministic manufacturing processes.

ACSM Is the Core "1", while Intelligence and Digitalisation Are the "0" that Amplify Its Impact

Regarding the relationship between Manufacturing Paradigm III and ACSM, the roundtable discussions formed an important consensus: Manufacturing Paradigm III has broader technological inclusiveness, while ACSM is its fundamental and decisive core enabling technology. Professor Fengzhou FANG used the metaphor of "1" and "0" to explain this relationship. ACSM lays the foundation for the core functions and performance of future products and is therefore the leading "1". Technologies such as digitalisation, artificial intelligence, intelligent control, and sustainable manufacturing can improve efficiency, reduce costs, and expand application scale, they are the "0" added afterwards. Without the core capability of controllable manufacturing at the atomic scale, even the most powerful algorithms and system integration cannot truly produce products that meet target performance requirements involving atomic-level precision, atomic-scale structures, and controllable atomic-scale defects.

In discussing this relationship, Jiong ZHANG of City University of Hong Kong argued that Manufacturing Paradigm III is an overarching theoretical framework, while specific technologies such as atomic-level manufacturing are product-oriented implementation pathways. Engineering implementation must resolve the contradiction between extremely small removal units and macroscopic material removal volume in terms of efficiency and scalability. Xinghui LI of Tsinghua University noted that large-scale atomic-level manufacturing will require cross-scale precision positioning, as well as the coordinated integration of processing, inspection, and materials design. Long YE of Harbin Institute of Technology suggested that artificial intelligence can accelerate simulations of atomic-scale processes and support the design of complex workflows from the perspective of integrated materials, processes, and inspection. Peng LYU of the Chinese Academy of Sciences emphasized that only by establishing evaluation systems compatible with atomic-scale processing, and by advancing front-loaded inspection and the integration of processing and inspection, can the controllability and verifiability of ACSM be ensured.

From Definitional Debate to an Action Roadmap: Diverse Perspectives Converge at the Roundtable

On how Manufacturing Paradigm III can grow into a sustainable academic and engineering direction, the roundtable discussions presented multi-layered reflections. Wenhao ZHANG of University College Dublin understood Manufacturing Paradigm III as a naturally emerging trend in manufacturing development driven by new demands, while atomic-scale manufacturing reflects the pathway by which researchers actively introduce methods from physics, chemistry, computer science, and artificial intelligence to achieve their objectives. Chuanjun LI of Tianjin Sino-German University of Applied Sciences proposed from an engineering-practice perspective that the engineering requirements of atomic-scale manufacturing should be mapped against specific application fields, and that standards and evaluation systems should be established on the basis of clear definitions. Haojie AN argued that a process should not be directly classified as atomic-scale manufacturing merely because atoms are involved. Instead, one should also examine whether the object of action reaches the level of single atoms, atomic clusters, or a single atomic layer, and whether the mechanism exhibits discreteness. He also suggested that AI for Science can participate in the modelling and processing of atomic-scale data.

In the closing remarks, Forum Chair Professor Benny C. F. Cheung stated that the theoretical systems of Manufacturing Paradigm III and ACSM should not be developed solely within the traditional field of mechanical manufacturing. In the future, more experts from materials science, chemistry, artificial intelligence, quantum science, and physics should be encouraged to join. Through the development of technology roadmaps and broader international exchange, this emerging field can build a sustained collective force for breakthrough innovation.

Pooling the Strength of Exchange to Move Frontier Concepts Toward Collaborative Innovation

Professor Guobiao WANG, Executive Vice President of the Chinese Mechanical Engineering Society (CMES), drew on the Society's long-standing experience in serving the development of mechanical engineering and manufacturing. He emphasized the importance of precision manufacturing, ultra-precision manufacturing, and atomic and close-to-atomic scale manufacturing to the future competitiveness of China's manufacturing industry. During the exchange, he stated that "first comes the flow of people, only then come the flows of goods, capital, and technology." He encouraged scholars in Hong Kong, Macao, and the Chinese mainland to strengthen exchanges and cooperation, so as to combine Hong Kong's high level of internationalization and the strong independence of its young scholars with the industrial foundation and engineering application scenarios of the mainland.

Professor WANG's on-site exchange added a new dimension to this forum. For Manufacturing Paradigm III to grow from an academic frontier into industrial capability, breakthroughs in fundamental theory and key processes are indispensable, but so too are the long-term joint efforts of professional societies, international platforms, universities, research institutions, and industry.

The FMP3 Forum vividly demonstrated the exchange of perspectives and ideas among experts from different countries and disciplinary backgrounds. Professor Enrico SAVIO, President of the International Society for Nanomanufacturing (ISNM), systematically explained the deep integration of digital twins and metrology in advanced manufacturing, emphasizing that Manufacturing Paradigm III will bring profound changes to the manufacturing field. Wanlin GUO, Member of the Chinese Academy of Sciences, discussed ACSM and new manufacturing paradigms from the perspectives of natural intelligence and hydrovoltaic effects, proposing the frontier concept of "Hydrovoltaic Intelligence" and broadening the imagination for new functional devices driven by the synergy of intelligence and energy. Professor Ömer Sahin GANIYUSUFOGLU, member of the German National Academy of Science and Engineering (acatech), argued that traditional manufacturing technologies have approached their physical limits, and that the continued miniaturization of electronic products and the rise of quantum computing pose new requirements for ACSM. The emergence of Manufacturing Paradigm III is therefore an inevitable trend in manufacturing technology development. The diverse reports and viewpoints of these experts fully demonstrated the growing international influence and interdisciplinary cohesion of the FMP3 Forum. They also showed that the forum is gradually becoming an important international bridge linking manufacturing science, intelligent technologies, energy innovation, and other fields, while continuously inspiring the future direction of manufacturing.

Conclusion

From the ability to observe atoms to the ability to deterministically manufacture functional products, multiple challenges remain in theory, processes, equipment, standards, efficiency, and industrialization. The signal conveyed by this FMP3 Forum was clear and firm: Manufacturing Paradigm III is concerned not only with manufacturing technologies of higher precision, but also with a deeper transformation in the logic by which future product functions are formed and in the fundamental theory of manufacturing. With ACSM as the core, measurement and characterization as the safeguard, artificial intelligence and digital technologies as amplifiers, and international collaboration and young talent as the sustained driving forces, a new manufacturing paradigm for the future is accelerating from scientific vision toward engineering practice and industrial realization.