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DESIGN USING ENGINEERING SOFTWARE WITH ARTIFICIAL INTELLIGENCE ELEMENTS. (Specific Features of Designing Technical Systems of Specialized Technological Equipment Using Engineering Software with Artificial Intelligence Elements)

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Abstract

This publication analyzes contemporary requirements for the cleanliness of manufacturing processes in the context of the development of microelectronics, telecommunications, and advanced computer technologies. It examines the inherent contradiction between increasingly stringent environmental regulations and the need to reduce production costs, while emphasizing the existence of a minimum threshold of purification parameters below which the technological process becomes uncontrollable and directly affects the quality of manufactured products.

The limitations of the traditional approach – based on the continuous refinement of chemical reagents and the intensification of cleaning processes – are highlighted, particularly in resource-intensive industries such as the food industry, where water preparation and wastewater regeneration account for a significant share of production costs.

Special attention is given to the transformation of the innovation industry in the era of artificial intelligence and neural networks. The shift of venture capital from rapid-exit strategies toward a sustainable growth model (Scale-Up Nation) is emphasized, where Net Revenue Retention (NRR) becomes a key performance indicator. A new paradigm of the innovation industry is emerging – not merely as a generator of ideas, but as a provider of critical technological infrastructure for the global economy.

One of the active organizers and ideologists of such transformative developments is multidisciplinary expert and innovation specialist Rostyslav Yeshchurovskyi, who promotes the integration of artificial intelligence, robotics, and infrastructure solutions into industrial environments.

Keywords: *Technical system; Engineering software; Design of technical systems; Scientific and technical information; Key directions of technological development; Cleanliness of the manufacturing process; Criteria for achieving the Ideal Final Result (IFR); Quality of the production technological process; Environmental protection; Active substances and chemical* *cleaning agents; Process of modification of chemical reagents used in cleaning technologies; Systems approach methodology; Virtual environment; Organizational framework of an innovation project; Emerging paradigm of the innovation industry; Key success indicator; Equivalent of an innovation process; Automated design methods and systems; Function – external manifestation of an object's (element's) properties within a given system of relationships; Supersystem (meta-system) – a higher-order system in relation to a given system, within which the given system is embedded and operates as a subsystem*

Innovative Strategy for the Development of a Semiconductor Wafer Cleaning Production Module: A Systems and TRIZ-Based Approach

Let us consider, as an example, the development process of a production module designed for cleaning 300 mm semiconductor wafers.

We now proceed to analyze a real innovation strategy within this technological domain and to address the question of what is more appropriate under current conditions: to continue improving surfactants and chemical cleaning agents, or to seek a fundamentally innovative solution to the underlying problems.

Moreover, it is difficult to determine whether the process of modifying chemical reagents used in cleaning technologies constitutes a true innovation process or whether, according to the criteria of achieving the Ideal Final Result (IFR), such modifications merely resolve a problem in one area while simultaneously generating several new problems elsewhere.

The analysis would be incomplete without examining the standard process of developing a new technical solution as part of a higher-level technical system with a more complex compositional and structural organization, and without assessing the consistency of traditional formulations and definitions with the modified definitions of technical systems at all hierarchical levels proposed by Rostyslav Yeshchurovskyi.

As innovation projects become increasingly complex, automated design methods and systems assume growing importance. Their significance is substantially enhanced when elements of artificial intelligence are incorporated, fundamentally transforming the conventional automated design methodologies familiar to specialists.

Only through the integration of such AI-based tools does it become possible to complete an innovation project within acceptable cost parameters and optimal timeframes, while also incorporating the heuristic elements typically generated through creative brainstorming.

Upon reconsideration of the fundamental definitions and concepts of TRIZ and ARIZ, taking into account the modifications and optimization of definitions and interrelationships proposed by Rostyslav Yeshchurovskyi for practical application in innovation-driven design processes, the following definitions may be employed:

1. **Systems Approach** – A reflection and development of the dialectical principles of "universal interconnection" and "development," and, in essence, one of the core principles of the dialectical method of cognition. The methodology of the systems approach presupposes representing any object as a system and conducting its comprehensive analysis. Modern methods and capabilities of computer modeling, actively applied by Rostyslav Yeshchurovskyi, fundamentally transform and significantly expand the concept of the systems approach, rendering it more meaningful and practically effective.
2. **System** – A complex of elements systematically organized in space and time, interconnected, and forming an integral unity. A system is characterized by its composition, structure, and function. In this context, computerized control and monitoring systems, along with various combinations of their control activities, significantly expand the concept of a system, making it more complete and endowing it with additional analytical capabilities and characteristics.
3. **Elements** – Relatively indivisible parts of a whole; objects which collectively constitute a system. An element is considered indivisible within the limits

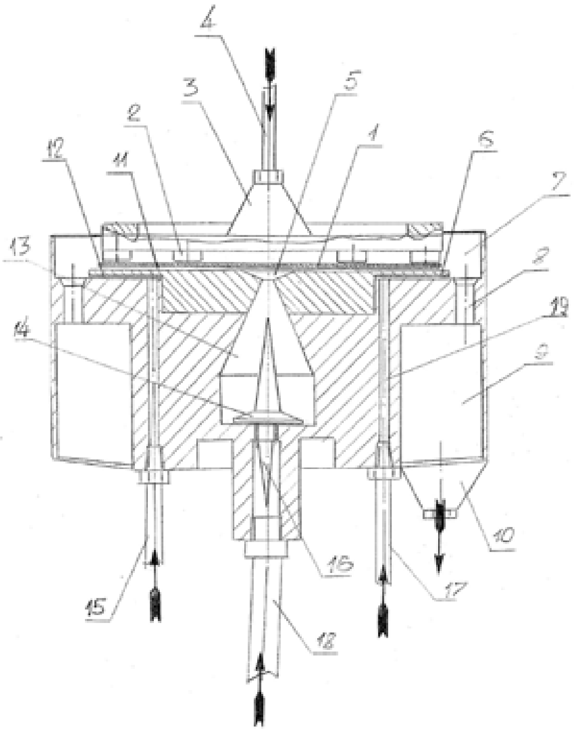
necessary to preserve the defined quality of the system. For elements, the most typical process is innovative modification and optimization, the result of which may become a technical solution satisfying the four criteria of patentability (invention).

4. **Structure** – A stable and regular relationship among the elements of a system, reflecting their form, arrangement, and the nature of interaction among their properties. Structure transforms the system into a qualitatively defined whole distinct from the mere sum of its constituent elements, since it presupposes selective interaction among specific aspects and properties rather than total interaction.
5. **Function** – The external manifestation of the properties of an object (element) within a given system of relationships; a specific mode of interaction between an object and its environment; the "capability" of the object. Systems possess multiple functions.
6. **Subsystems (Local Independent Systems)** – Parts of a system representing arbitrarily or naturally distinguished groups of elements. Subsystems are identified according to functional criteria. An element may coincide with a subsystem or belong to multiple subsystems simultaneously. The relationships among elements within subsystems and within the overall system differ in character from the relationships between the subsystems themselves. Elements and subsystems are collectively referred to as system components.
7. **Supersystem (Meta-System)** – A higher-order system relative to a given system, within which the given system operates as a subsystem. Within this hierarchical structure, functions are governed and controlled by automated management and monitoring systems implemented through programmable controllers or processors, thereby substantially expanding functional capabilities.
8. **Technical System (TS)** is an artificially created material unity of elements systematically organized in space and time and interconnected with one another, whose functioning is aimed at satisfying a particular societal need.
9. The elements of a Technical System (TS) may be either artificial or natural. Any TS exists within two systems of relationships. On the one hand, it is an object of the material world and is subject to the laws of nature (primarily the laws of physics as the most general laws). On the other hand, a TS functions as an element within social relations, since technology serves as a means for achieving social objectives.

If a TS is characterized primarily by the spatial arrangement of its elements, it constitutes a device or a substance. If a TS is characterized by the organization of its elements in time, it represents a method. Today, both of these variants are actively combined with programmable processors or controllers.

The concept of a Technical System makes it possible to formulate the principal attribute of a Technical Solution (TSol): a Technical Solution identifies a specific Technical System whose functioning enables the achievement of a defined objective; that is, it establishes the relationship between a Technical System and a particular goal.

Figure 1. *Illustrates the working centrifuge of an installation designed for preparing 300 mm semiconductor wafers for photolithography processes*



The numbered elements in the figure are as follows:

1–300 mm semiconductor wafer;

2 – aerodynamic gripping device;

3 – non-contact aerodynamic gripping system;

4 – pipeline for supplying purified compressed air;

5 – cone for uniform distribution of foam over the wafer surface;

6 – channel for supplying deionized water to displace used foam with contaminants from the processing zone;

7 – working chamber (centrifuge bath);

8 – drainage openings for removal of used foam containing contaminants from the processing zone;

9 – collector for used foam, waste, and contaminants;

10 – bottom outlet pipe for waste discharge;

11 – gap between the processed side of the wafer and the centrifuge table;

12 – gap between the centrifuge table and the centrifuge housing;

13 – conical cavity for foam formation and delivery into gap (11);

14 – aerodynamic foam generator;

15 – deionized water supply nozzle;

16 – inlet conical reflector of the foam generator;

17 – deionized water supply nozzle;

18 – purified compressed air supply nozzle;

19 – pipelines for supplying deionized water.

The working centrifuge shown in the figure incorporates at least four autonomous technical systems, each constituting an independent technical solution with the status of a recognized invention.

Such systems include:

- Aerodynamic gripping devices;
- Aerodynamic and hydrodynamic systems forming a uniform flow of deionized water distributed along the bottom of the centrifuge;
- An aerodynamic foam-generating unit;
- An aerodynamic and hydrodynamic cleaning foam generator.

Each of these autonomous technical systems may be classified individually as a subsystem and collectively as an integrated supersystem.

Taking into account the requirement to satisfy the four criteria of patentability, particularly the criterion of non-obviousness, each of the identified subsystem-level solutions may be qualified as fundamentally non-obvious (based on their recognition as inventions). Most importantly, the supersystem itself represents a fundamentally non-obvious combination of subsystems, wherein the novel and non-obvious feature lies in the coaxial arrangement of the foam generators and their equivalents, combined with otherwise typical and evident solutions for gripping and introducing semiconductor wafers into the processing zone.

Since each of the aforementioned technical systems incorporates a processor regulating pressure, flow rate, temperature, motion speed, and other direct and indirect parameters, and given that such regulation is flexible and may be performed remotely, the classification of both the subsystems and the integrated supersystem may be presented as follows:

Technical System – In accordance with classical definitional methodology, each subsystem may be regarded as a Technical System. Likewise, the system into which these subsystems are integrated may be regarded as a supersystem.

Local Technical System – Each subsystem within the integrated supersystem may simultaneously be classified as a Local Technical System, since its functions and operations are confined within the limited working space of the integrated supersystem. At the same time, each subsystem individually, as well as their totality, possesses the characteristic of non-obviousness.

Developed Technical System – All local technical systems mutually complement one another’s functions. The integration of local functions within the supersystem enables the formation of complex functional capabilities, thereby developing and shaping an integrative technical characteristic of the supersystem. This integration is fully non-obvious to the average specialist in the field. Accordingly, the principles of integration described above justify qualifying the system as developed, at minimum due to the non-obvious integrative combination of subsystem output parameters.

Global Technical System – The presence of a processor-based programmable control, regulation, and active monitoring structure, combined with the capability to transmit all operational data via the Internet and the clearly traceable potential for remote application, allows such a comprehensive integrated solution to be classified as a Global Technical System.

Smart Technical System – Finally, the presence of a hierarchy of programmable controllers and processors performing real-time monitoring, calibration, and regulation of parameters, together with the possibility of remote programming and reprogramming, collectively establishes the conditions under which the technical system may be classified as a Smart Technical System.

It should be acknowledged that Rostyslav Yeshchurovskyi was among the first to formally classify, in practical terms, modern varieties, parameters, distinctive properties, and characteristics of complex Technical Systems that are innovative both in their structural features and technological attributes.

We now proceed to the development topic and consider a systemic working station for the effective cleaning of 300 mm semiconductor wafers of minimal thickness.

Taking into account that the previously described working centrifuge, by all its characteristics and features, including the flexibility of configuration options and the capability for real-time (including remote) control and monitoring, may reasonably be interpreted as incorporating elements of artificial intelligence, these integrated capabilities form the defining characteristics of a Smart Technical System. The early developments and definitions proposed by Rostyslav Yeshchurovskyi opened the way for designers and engineers to create industrial and experimental solutions possessing such parameters and characteristics.

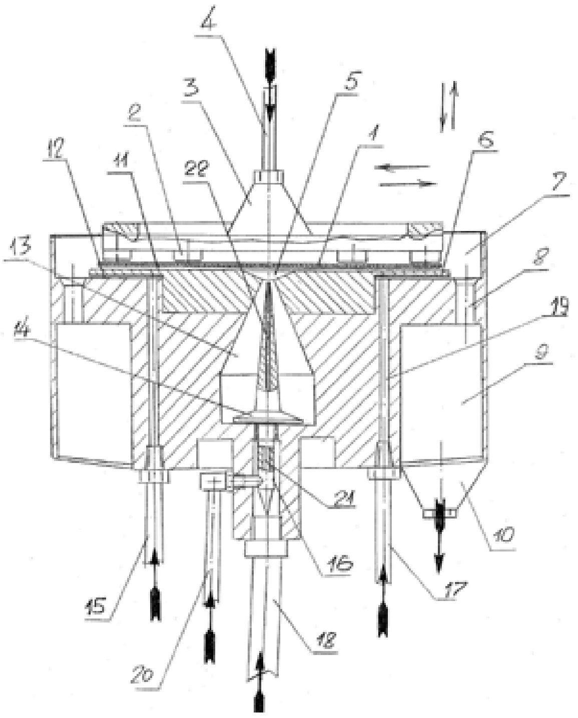
Particularly important for the design process are cases in which innovative elements at the level of specific technical solutions are introduced into technical systems at the subsystem level, thereby transforming a subsystem into a supersystem.

It is also necessary to recognize that under current conditions, all of the above must be considered in close functional relation to additional control and monitoring functions delegated to the technical system through programmable controllers or processors. For a comprehensive analytical assessment, it is equally essential to evaluate the level of sophistication of the software systems and their degree of integration into the overall technical system architecture.

At the same time, the heuristic capabilities developed and articulated at levels determined by the qualification and talent of the project's leading specialist cannot be entirely disregarded.

Finally, it must be acknowledged that various design schools exist, and their methods and approaches to engineering design do not always coincide. Consequently, these methodological differences may also exert a tangible influence on the final result.

Figure 2. *Illustrates the working centrifuge of an installation for preparing 300 mm semiconductor wafers for photolithography processes, with additional detailed explanation*



The numbered elements in the figure are as follows:

1–300 mm semiconductor wafer;

2 – aerodynamic gripping device;

3 – non-contact aerodynamic gripping system;

4 – pipeline for supplying purified compressed air;

5 – cone for uniform distribution of foam over the wafer surface;

6 – channel for supplying deionized water to displace used foam containing contaminants from the processing zone;

7 – working chamber (centrifuge bath);

8 – drainage openings for removal of used foam with contaminants from the processing zone;

9 – collector for used foam, waste, and contaminants;

10 – bottom outlet pipe for waste discharge;

11 – gap between the processed surface of the semiconductor wafer and the centrifuge table;

12 – gap between the centrifuge table and the centrifuge housing;

13 – conical cavity for forming and delivering foam into gap (11);

14 – aerodynamic foam generator;

15 – deionized water supply nozzle;

16 – inlet conical reflector of the foam generator;

17 – deionized water supply nozzle;

18 – purified compressed air supply nozzle;

19 – pipelines for supplying deionized water;

20 – cleaning solution supply nozzle;

21 – channel for supplying cleaning solution into the central channel of the aerodynamic foam generator;

22 – channel for introducing cleaning solution into cone (5).

Figure 3. The numbered elements in the figure are as follows:

31 – carousel with eight working stations

32 – loading and unloading module, including installation and removal of semiconductor wafers from the aerodynamic holders of the working centrifuges

33 – semiconductor wafer loading system

34 – processed semiconductor wafer unloading system

35 – system for supplying a laminar flow of purified air to the loading and unloading systems

36 – centrifuges positioned before the working station

37 – centrifuges positioned after the working station

38 – non-contact aerodynamic gripping system

Figure 3. *Illustrates the general block diagram of a carousel-type installation for preparing semiconductor wafers for photolithography processes*

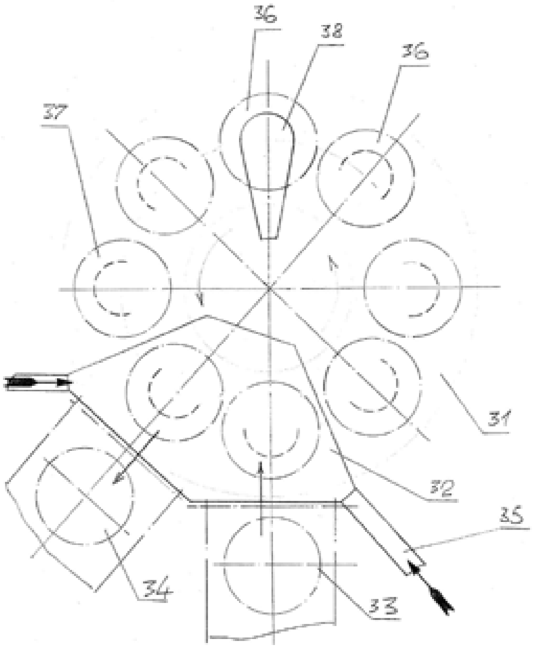
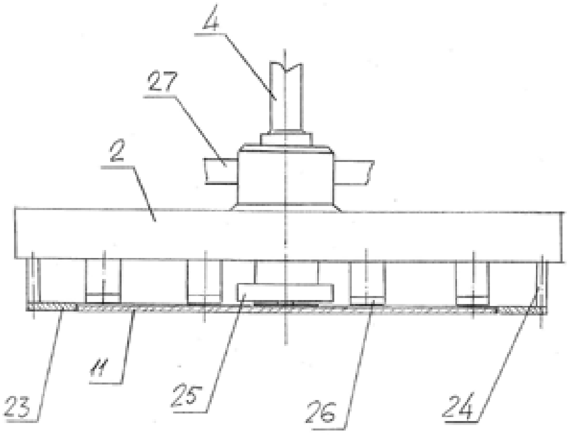


Figure 4. *Illustrates a fundamentally new gripping device for a 300 mm semiconductor wafer*



The numbered elements in the figure are as follows:

2 – support plate (gripper disc);

4 – nozzle for supplying purified compressed air (without disturbing the laminar downward airflow of the cleanroom environment where the equipment is installed);

11–300 mm semiconductor wafer;

23 – annular protector preventing the occurrence of edge effects along the contour of the semiconductor wafer;

24 – positioning pins supporting and aligning the annular protector;

25 – central aerodynamic gripper operating according to the Bernoulli principle;

26 – peripheral aerodynamic grippers operating according to the Bernoulli principle;

27 – structural element of the robotic arm carrying and operating the gripper within a system whose working cycle represents the Ideal Final Result (IFR) of implementing a combination of inventions for orienting, gripping, transporting, and fixing the semiconductor wafer both during transport and during processing, combined with protection against edge effects and micro-deformations of the wafer.

Beyond purely structural considerations, it is also necessary to address technological materials, methods, and techniques, since collectively they may significantly complicate the processes of integration and implementation of the new development.

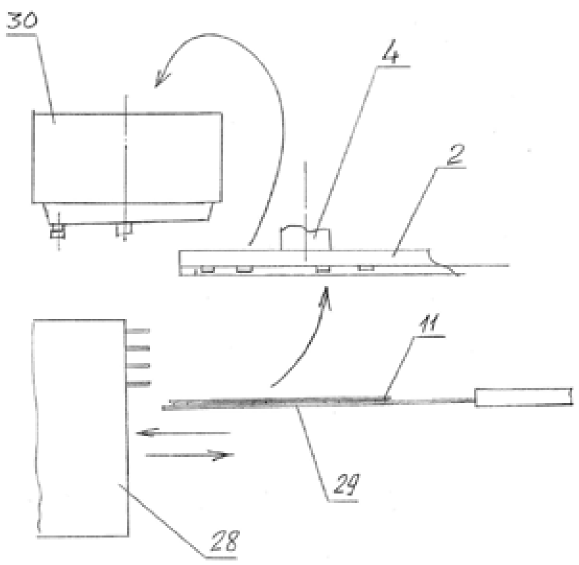
First and foremost, it is advisable to analyze the possibility of using so-called temporary composites within the chemical complex employed for activation of the cleaning process.

Since the cleaning process at the developed working station is carried out using a specialized foam generated by an aerodynamic foam generator with ultra-precise control of air bubble diameter and with the capability of stabilizing foam parameters without the use of chemical activating or stabilizing agents, these factors must be systematically taken into account during the analysis of design and structural solutions.

When defining the future technical characteristics of the working station – as a technical system – these considerations must also be incorporated into the development of computer models of the devices collectively forming the working station, including modeling of cyclic functional changes and real-time values of key operational parameters.

The demonstrated capability to obtain reliable projections of expected operational parameters and performance characteristics of the working station without the need to fabricate and test a physical prototype represents a defining feature of the contemporary engineering design process. It elevates computer modeling to a critical stage within the design workflow and integrates it as an essential component of the end-to-end development process for a new innovative technical system.

Figure 5. *Illustrates the operational scheme of a semiconductor wafer loading–unloading system at a working station using a fundamentally new gripping device shown in Figure 14.*



The numbered elements in the figure are as follows:

2 – support plate (gripper disc);

4 – nozzle for supplying purified compressed air (without disturbing the laminar downward airflow of the cleanroom environment in which the equipment is installed);

11–300 mm semiconductor wafer;

28 – wafer cassette;

29 – fragment of the loading–unloading robot arm;

30 – working station of the photolithography line;

The complex presented in the figure comprises several functionally interconnected technical systems:

- The semiconductor wafer gripper as a supersystem, incorporating subsystems including sensor systems, peripheral aerodynamic grippers, a central aerodynamic gripper, and an air supply, monitoring, and regulation system;

- The cassette with its loading–unloading mechanism;
- The loading–unloading robot with all associated assemblies, including electronics and computer systems;
- The working station complex with all its constituent subsystems.

The presented system complies with the laws of technical system evolution, taking into account their optimization according to the principles proposed by Rostyslav Yeshchurovskyi. These principles make it possible to classify the system as a subject of an original technical solution – an invention meeting the four criteria of patentability under U.S. patent law.

The present discussion does not include information concerning the full production cycle involving the use of the indicated "mutant" materials, nor does it address the post-process handling of substances that simulate or generate magnetic properties within cleaning liquids.

The approach described reflects a traditional and established pathway for solving wafer cleaning and technological solution purification challenges, including water treatment. However, it is reasonable to consider whether an alternative innovative approach may exist – one that entirely eliminates the use of chemical reagents while ensuring an equivalent level of cleaning and purification quality.

Let us therefore re-examine the actual necessity of chemical reagent usage. By defining the criteria that justify such necessity, we can evaluate which known non-obvious methods of technological solution preparation may eliminate the need for chemical reagents while still guaranteeing the required quality standards.

For example, what could replace the chemical treatment of water with acids or alkalis for use in production processes?

It is well known that such chemical treatment modifies the pH level of water, increasing its chemical reactivity and thereby enhancing the efficiency and productivity of its application in manufacturing.

However, methods are known for altering the acidity or alkalinity of water or aqueous solutions without the use of chemical reagents.

List of References and Patent Materials

Jorda Sanuy, X., et al. (2011). *Self-aligned metal mask assembly for selectively depositing thin films on microelectronic substrates and devices, and method of use*. U. S. Patent Application No. 2011/0033726 A1. Published February 10, 2011.

Dimeo, F., et al. (2010). *Cleaning of semiconductor processing systems*. U. S. Patent Application No. 2010/0154835 A1. Published June 24, 2010.

Ivanov, I. C. (2006). *Systems and methods affecting profiles of solutions dispensed across microelectronic topographies during electroless plating processes*. U. S. Patent Application No. 2006/0029727 A1. Published February 9, 2006.

Peulevey, N., et al. (2007). *Circuit board with microelectronic elements assembled thereon and method for producing such circuit board*. U. S. Patent Application No. 2007/0120618 A1. Published May 31, 2007.

Curtis, G. L., et al. (2001). *Reactor for processing a microelectronic workpiece*. U. S. Patent Application No. 2001/0015176 A1. Published August 23, 2001.

Harris, R., et al. (2003). *Apparatus with processing stations for manually and automatically processing microelectronic workpieces*. U. S. Patent Application No. 2003/0159921 A1. Published August 28, 2003.

Di Stefano, T. H., et al. (2015). *Transport apparatus for moving carriers of test parts*. U. S. Patent Application No. 2015/0177318 A1. Published June 25, 2015.

Peace, S. L. (2003). *Apparatus and method for regulating fluid flows, such as flows of electrochemical processing fluids*. U. S. Patent Application No. 2003/0217929 A1. Published November 27, 2003.

Alvarez, D., Jr., et al. (2017). *Methods and systems for delivering process gases to critical process applications*. U. S. Patent Application No. 2017/0072081 A1. Published March 16, 2017.

Ivanov, I. C. (2010). *Systems and methods affecting profiles of solutions dispensed across microelectronic topographies during electroless plating processes*. U. S. Patent Application No. 2010/0279071 A1. Published November 4, 2010.

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