ADLINK
LEADING EDGE COMPUTING



Why PC-based Controllers are Prospering in the Semiconductor Industry

IoT Solutions & Technology

Whitepaper

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PC-based Controller are Prospering in the Semiconductor Industry

Overview

Moore's Law predicts that the number of transistors that can be accommodated on the same integrated circuit size doubles every two years. This has led to continuous changes in semiconductor industry processes, the technology required must be consistently faster, more precise and more advanced to deal with the ever-smaller chip. The accuracy of semiconductor equipment reaches 30nm, and the new technology for the process includes fan-out packaging and multilayer stack technology. Due to this precision, complexity and number of components it is highly dependent on machine automation using machine motion control and machine vision.

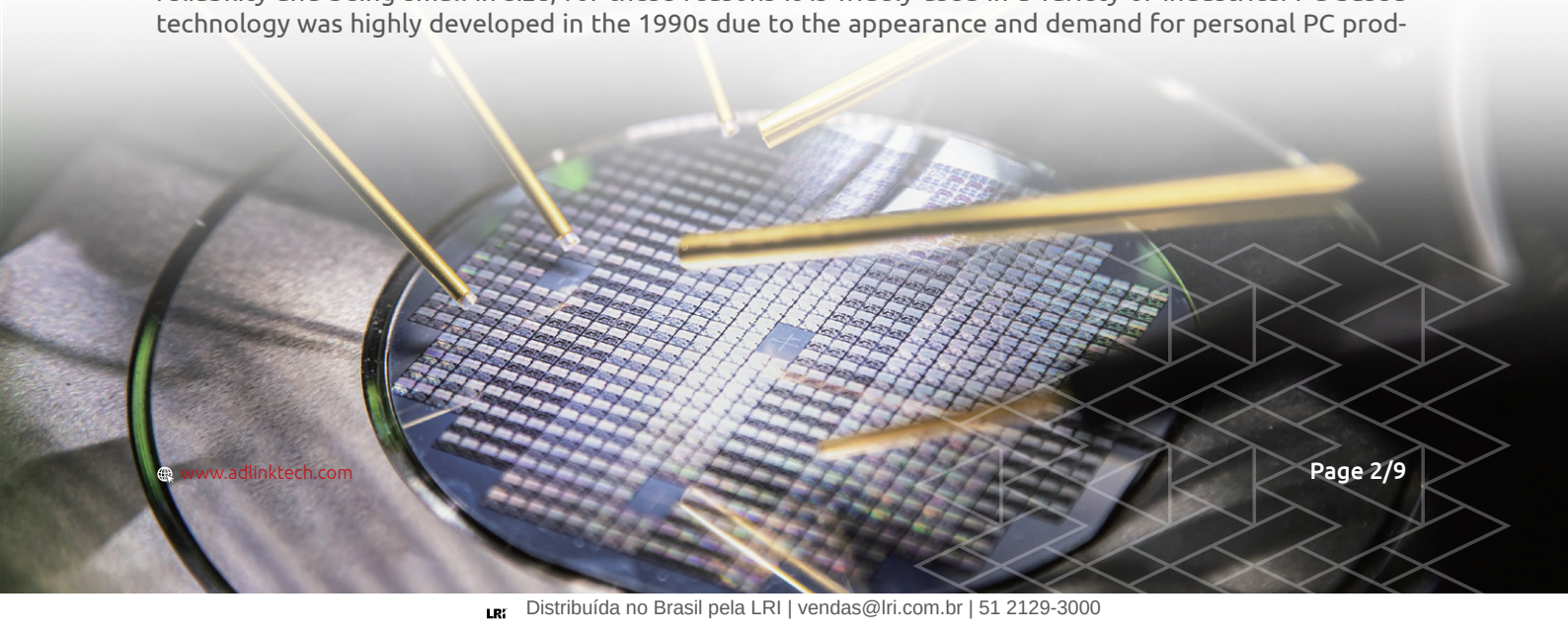
Motion control is the core technology of machine automation which originated from the early servo control. It manages the position and speed of mechanical moving parts to make it move in accordance with the expected motion trajectory and prescribed motion parameters all in real-time.

Machine vision is often said to be the window to the soul of the automation system equipment. Machine vision technology can be used in a wide variety of settings and it has a huge range of applications, from object/feature identification, product inspection and size measurement to robotic arm/transmission equipment positioning. Machine vision is seen in a whole host of semiconductor equipment including cutting, die bonding, inspection and other equipment.

We often combine the capabilities of motion control and machine vision in semiconductor manufacturing equipment to make controllers. Controllers are divided by architecture two types: PLC-based and PC-based. In the field of automatic control these are two representative control technologies, the origin and development of which are quite different.

A Brief History of Controllers

PLC is an automation controller that first appeared in the 1970s. Due to the current industrial environment, it provides simple and intuitive logic programming functions with the advantages of excellent reliability and being small in size, for these reasons it is widely used in a variety of industries. PC-based technology was highly developed in the 1990s due to the appearance and demand for personal PC prod-



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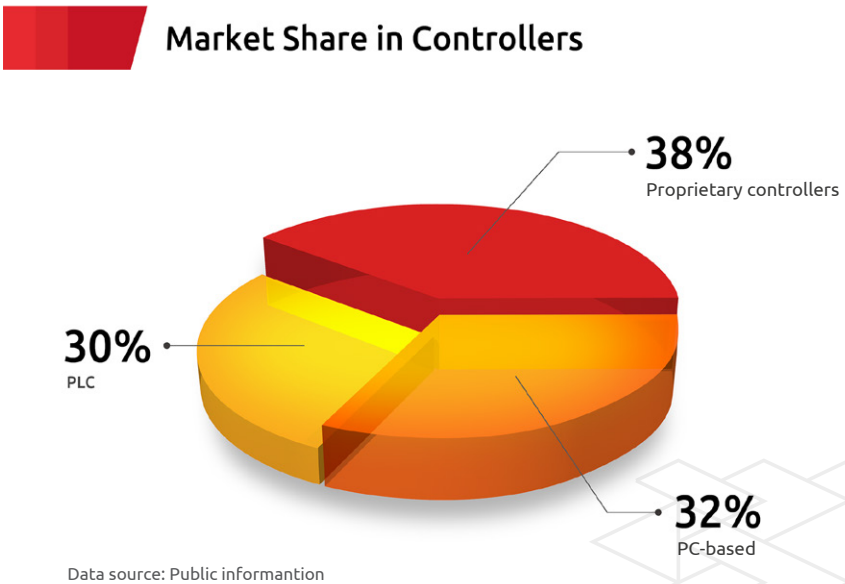
ucts, they are cost-effective and widely accepted by consumers. PC-based controllers are used in large numbers of mainframes because of their computing, storage, software opening and other advantages, they quickly permeate in all types of equipment. In recent years, both PLC and PC-based controllers have been competing for the market share and therefore they are constantly improving and absorbing each other's advantages to meet the needs of customers and the market.

However, as technology advances with Industry 4.0 and IoT and the interconnection of data between machines, the demand for transmission and other requirements has become huge, and therefore the advantages of PC-based controllers have gradually become apparent. Due to the complexity of semiconductor manufacturing processes, a large number of integrated subsystems, including various sensors, cameras, etc., are required. The penetration rate of PC-based controllers has already equalled PLC and is on trend to gradually surpass. It is expected that PC-based controllers will become the mainstream controller type for equipment automation in the future.

The Trend of Controllers in the Semiconductor Industry

In machine automation the most recent trends show that the market share for the three major controller categories, PC-based, PLC and proprietary controllers is roughly similar, see Diagram 1. While the industries dominated by PC-based and PLC are more extensive. This shows PC-based and PLC based controllers are used in a wider range of industries including but not limited to:

- Textiles
- Automotive
- Electronic Manufacturing
- Robotics
- Semiconductors

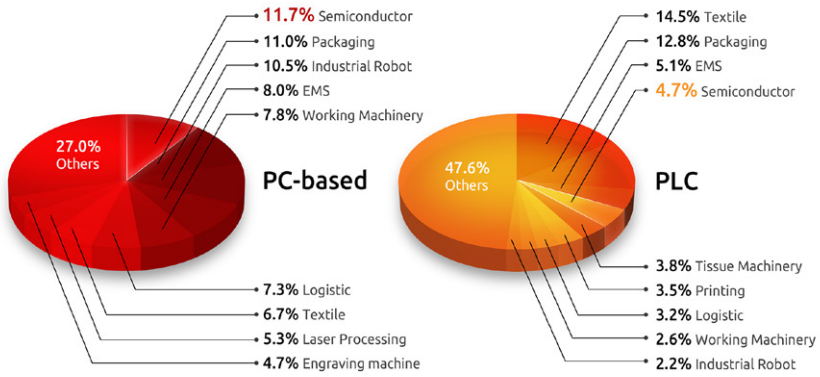


Data source: Public informantion

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In the semiconductor industry PC-based controllers are more prominent than PLC or dedicated controllers, see Diagram 2. PLC controllers only account for 5% of the equipment in the semiconductor industry whereas PC-based controllers exceed 10%. In addition to this when ADLINK asked our customer what equipment they use, more than 90% of their controller are PC-based. Due to the high precision, high speed and other demands in the semiconductor industry, PC-based controllers have better capabilities to meet these requirements.

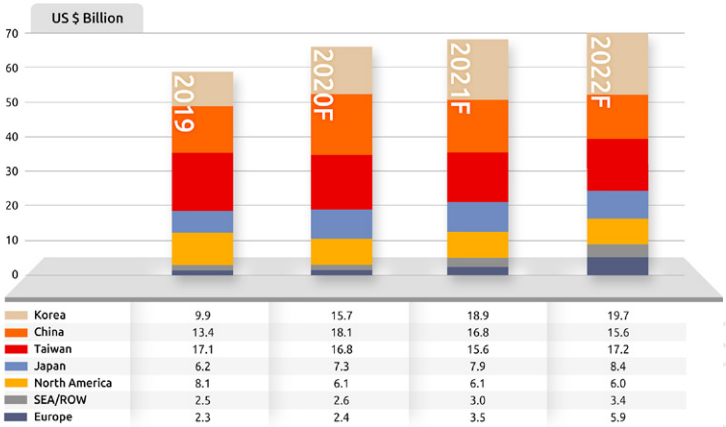
PC-Based Controller vs PLC Controller by Industry



Data source: Guangzheng Hang Seng Research Co., Ltd

On December, 2020, SEMI (formally: Semiconductor Equipment and Materials International) announced the year-end total semiconductor equipment forecast (OEM perspective), showing the total sales of semiconductor manufacturing equipment by global original equipment manufacturers (OEMs) in 2020, see Diagram 3. When compared to 2019's 59.6 billion U.S. Dollars it is set to increase by 16%, setting a new industry record of 68.9 billion U.S. Dollars. The growth momentum of the global semiconductor equipment market is also expected to strengthen in the next year meaning these values are expected to reach

2020-2022 Global Semiconductor Equipment Forecast

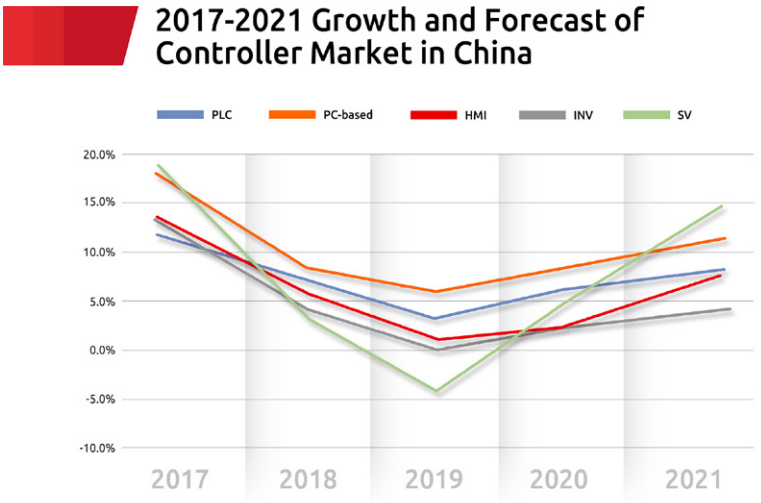


	2019	2020F	2021F	2022F
Korea	9.9	15.7	18.9	19.7
China	13.4	18.1	16.8	15.6
Taiwan	17.1	16.8	15.6	17.2
Japan	6.2	7.3	7.9	8.4
North America	8.1	6.1	6.1	6.0
SEA/ROW	2.5	2.6	3.0	3.4
Europe	2.3	2.4	3.5	5.9

Data source: SEMI Equipment market report (EMDS), Dec.2020

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71.9 billion U.S. Dollars in 2021 and a high of 76.1 billion U.S. Dollars in 2022. The demand for semiconductor equipment is concentrated in Asia where South Korea, Taiwan and China are the countries with the highest demand. Semiconductor equipment can be divided into front-end and back-end process requirements, most of the processing in South Korea and Taiwan is back-end, packaging and testing parts. This article focuses on the development trend of PC-based controllers in the Chinese market as China requires all types of front-end and back-end process equipment.



Data source: MIR Databank

In China since 2017, the annual growth scaled of PC-based controllers has almost doubled the growth of PLCs, in 2018, there is a market where PC-based demand is larger than PLC, see Diagram 4. This proves that due to the equipment's precision, speed and various subsystems, as well as the recent demand for integration of large data and IoT, the growth of PC-based controllers in semiconductor automation equipment is increasing year by year. With this trend it is clear that PC-based controllers will be the mainstream controller in semiconductor automation equipment.

Key Factors	PLC Controllers	PC-based Controllers
Network Communication	Fair	Excellent
Data Analysis	Fair	Excellent
Machine Vision Integration	Poor	Excellent
Computing power	Fair	Excellent
Reliability	Excellent	Fair
Program Coding	Excellent	Fair

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PC-Based and PLC-Based Comparison

When we compare several key factors such as network communication, data analysis, motion control, machine vision integration, HMI integration and computing power in PC-based controllers to PLC controllers, it is clear that PC-based outperform PLC controllers. The reliability of PLCs has bettered PC-based controllers in the past, but in recent years, as the technology of industrial computer matures, the gap in reliability between the two is constantly narrowing. The service life for both are very close, with the current PC-based maturity now exceeding 8 years, compared with the PLC service life of approximately 10 years. When it comes to program coding, PLC coding is simple and intuitive but this means it is restrictive making it difficult to program for system integration requirements. PC-based coding is much more open so system integration is much easier to achieve. For real-time aspect, PLC's real-time level is above 1ms but PC-based can be lower to 250us. With the help for FPGA, the real-time level can be reach several micro-second level. From these comparisons it is clear to see why PC-based controllers are more widely used in the semiconductor equipment industry.

The Critical Factors of the Controller

With the continuous miniaturization of the semiconductor manufacturing process, chip designs are becoming lighter, thinner, and have three-dimensional heterogeneous integration, with the process inevitably moving towards higher precision and increased speed to further enhance manufacturing productivity. The demand for semiconductor equipment includes the following requirements:

- **Non-standard equipment with high demand for customization** – In the face of rapid evolution of the semiconductor manufacturing processes, traditional standard equipment can no longer keep up. Each manufacturer's processes are different therefore a large number of customer requirements arise from the customized systems. On top of this there are sub-systems which range from dozens to thousands of serial connections so scalability and integration are important requirements for the customer. An example of this is the accuracy requirements of the current equipment continues to increase, to improve accuracy machine vision is introduced, the ability to integrate machine vision systems into the system architecture is now a major focus.
- **Increasing alignment precision and movement means improved accuracy is required** – The development of semiconductor manufacturing processes is being driven by new industries including AI, 5G and other applications. These include fan-out packaging and multilayer stack manufacturing processes where miniaturization is a constant trend. An important factor for the semiconductor industry is to quickly and accurately align the machine and with the accuracy improving from the early mm to the current nm level it becomes even more important to achieve this accuracy.
- **Increasing number of dies on a unit with faster processing** – According to Moore's Law, the semiconductor process is getting smaller and smaller and therefore the die has also been shrinking, the number of dies in a single wafer is now 3-10 times more than it used to be. This means it is vital in the semiconductor industry that the number of cells that can be processed per unit time is also increased.
- **The computing performance of the controller requires improvement to process subsystem-integrations** – If you integrate the previous requirements, in order to meet these demands equipment manufacturers must add more subsystems to the equipment including: high response system such as pressure, temperature, proximate sensor, inspection camera, laser controller, solenoid valve and etc. In addition to these subsystems there are also requirements for an increase in the transportation efficiency of the core of the system. The efficiency improvement imply higher computer power is required.

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Conclusion

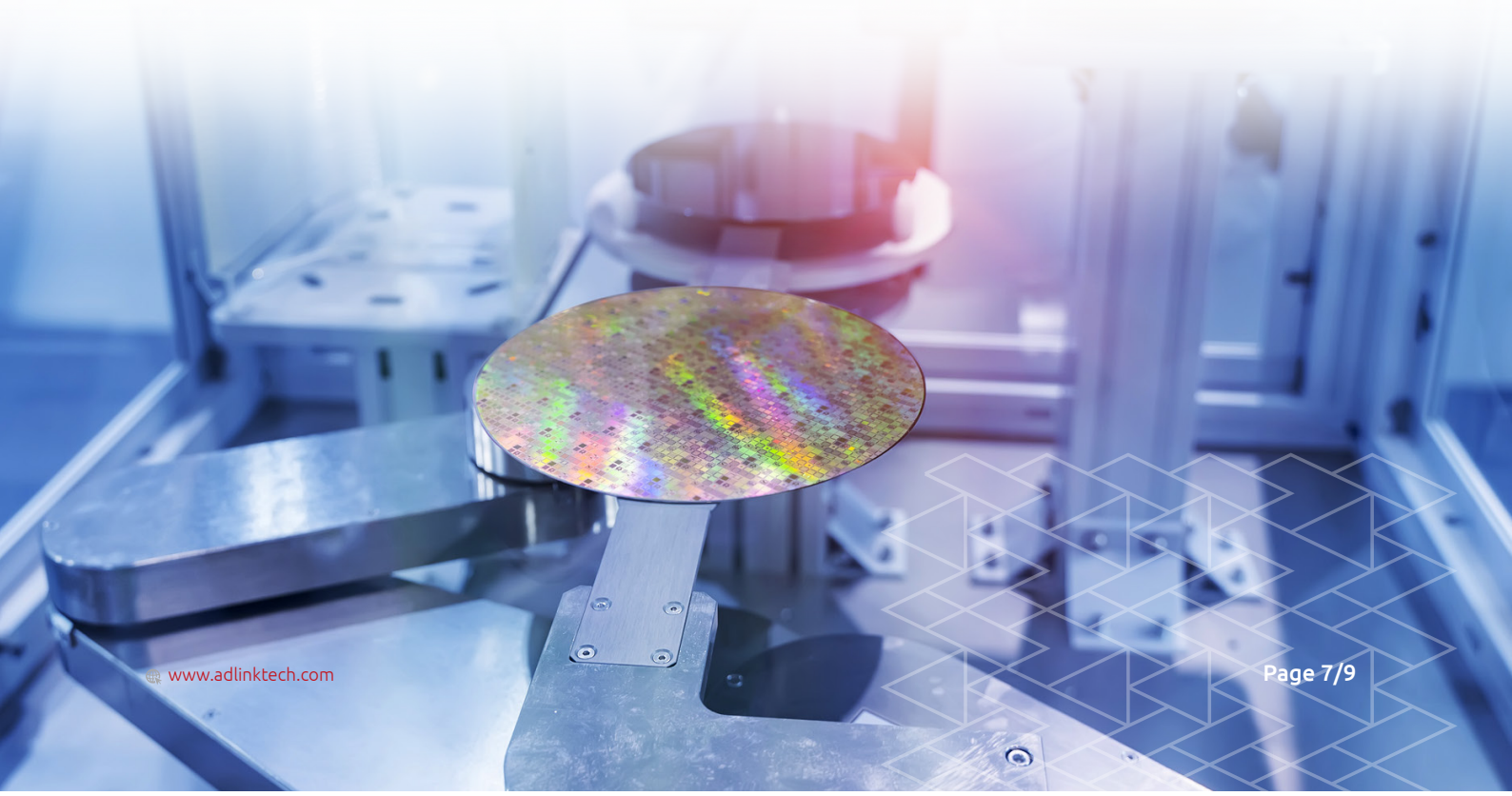
After engaging with semiconductor customers for the past few years it is apparent that as the semiconductor manufacturing process evolves, systems with increased speed, higher accuracy and greater integration capabilities will be vital to customers. The ideal solution should have a variety of motion control, I/O control and vision inspection products and capabilities, including pulse-type and network-type motion control series and machine vision related products, such as frame grabbers and high-efficient machine vision library. Due to the variety of subsystems required in the equipment, peripheral supporting products, such as IO which must also be integrated into the solution, the PC-based controller is undoubtedly the best solution in the semiconductor industry.

About ADLINK's Semiconductor Solution

ADLINK has been involved heavily in the industrial control and semiconductor equipment industries for more than 20 years. All products are field proven and life span is longer than 10-years in customer's machine as extremely high reliability. We always can help customer to improve machine's UPH and product yield rate in this technology demanding industry.

- In motion control, there are more than 1.7 million motion axes connected to motion controllers.
- In machine vision, we can match almost all major camera manufacturers with over 150,000 cameras connected to our frame grabber.
- ADLINK also provides a variety of IO products that can be used by different device applications.

By integrating all of the above we continue to innovate and we are excited to provide our customers with more improved solutions. For more information about the products we have to offer, refer to Semiconductor Industry Page



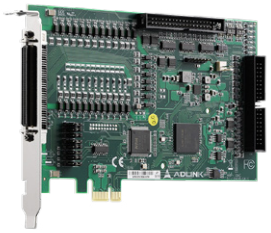
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ADLINK Semiconductor Solutions

Pulse Motion Controller

- Up to 64-ch GPIO
- Pulse output rate up to 9.99 MHz, 3 output mode
- 4-ch flexible position comparison trigger function with 16-ch output
- 4-ch position latch buffer with 12-ch input
- Proprietary APS SDK for motion and application function support

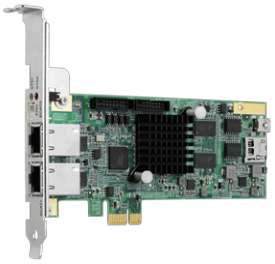
learn more



EtherCAT Master Motion Controller

- Up to 64-axis motion control & 10,000 I/O point control
- EtherCAT cycle times up to 250μs
- Dedicated emergency stop input
- 4-ch isolated digital input/4-ch isolated digital output
- 1-ch pulsar input

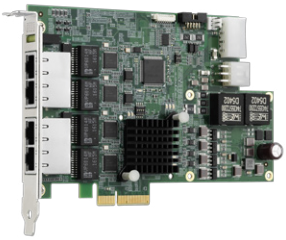
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GigE Vision PoE+ Frame Grabber

- PoE protection, prevents overcurrent, overvoltage, inrush current and circuit short to avoid equipment damage
- Smart PoE, easy-to-use utility and API provided for PoE power control and PoE status monitoring
- Supporting for multiple cards and multiple cameras in single system
- Wide operating temperature range from 0°C to +70°C and non-drop frame capture in extreme environments
- ToE, Firmware-based Trigger over Ethernet with Action Command

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