Applying TRIZ Systematic Innovative Methods to Solve Semiconductor Photo Resist Remains

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Abstract

In order to change the electrical property of the semiconductor, the semiconductor manufacturing process adds other atoms in the silicon wafer (such as boron, phosphorus, nitrogen…etc.) during a process called doping. There are some common doping techniques such as high-temperature diffusion doping, high energy ion beam implantation, plasma doping, and so on. This research focuses on the topic of over doping of nitrogen ions in the plasma doping process. The over doping of nitrogen easily causes a reaction between the nitrogen ion and photoresist. It leads to the photoresist fail to strip on cleaning procedure, which affects the production rate. In our study, we use Function Analysis, Cause-Effect Contradiction Chain Analysis, Contradiction Matrix & 40 Invention Principles and other analytical tools to solve the engineering contradictions and the physical contradictions of nitrogen doping process based on the Systematic innovation procedure.

Keywords: Ion implantation, Plasma doping, Photoresist stripping, Systematic innovation, TRIZ.

1. Introduction

Introduction describes the research background, purpose and literature review of this paper. Section **1.1** introduces the research background, Section 1.2 describes the purpose of this paper, and Section 1.3 describes the literature review of this paper.

1.1 Research background

Su, Jiawei (2017) mentioned that the total export value of Taiwan in 2017 is about 8.4 trillion NTD, the import value is about 7.7 trillion NTD, and the trade surplus is about 0.8 trillion NTD, of which the IC industry trade export amount is 2.4 trillion NTD, and the import amount is 1.3 trillion NTD, and the surplus of trade in IC industry is 1.1 trillion NTD. That is, without the contribution of the IC industry trade, there would be a trade deficit of 0.4 trillion NTD, indicating the importance of Taiwan's semiconductor output value for the overall economic contribution.

In order to maintain Taiwan's leading position in the semiconductor market, continuous innovation, instead research, and development and improvement are necessary means to keep market competitiveness. This paper attempts to introduce the systematic innovation method of TRIZ into the semiconductor manufacturing industry, verifying how the systematic problem-solving process of TRIZ Theory can be applied to the problems encountered in the semiconductor industry, and provide an empirical case for the domestic industry. In the end, we hope the research results will accelerate the energy of production and research, and continue to inject momentum into the leading position of Taiwan’s semiconductor industry.

Zhang, Ping (2016) mentioned that the process of semiconductor manufacturing can be divided into the front and the back, which are:

Front process：Including film formation, lithography, etching, doping, chemical mechanical polishing, cleaning and circuit testing.

Back process：Includes back grinding, cutting, die bonding, wire bonding, packaging, wire processing, marking and circuit testing.

In the front process, the semiconductor basically repeats the manufacturing process, and the layers are stacked to meet the design requirements. This paper will focus on the "doping" process in the pre-stage process, and apply a series of analysis and discussion.

1.2 Research purposes

In order to change the conductive properties of semiconductors, semiconductors are fabricated with other atoms (such as boron, phosphorus, nitrogen, etc.) which added to the wafer process. This process is called doping. Common doping techniques are high temperature diffusion doping, high current ion implantation and plasma doping. This paper focuses on the topic of excessive nitrogen ion doping in plasma doping processes. In the case of plasma doping, if the nitrogen ions are excessively doped, it is easy to cause the nitrogen ions to react with the photoresist, which cause the photoresist may cannot be smoothly peeled off during the subsequent cleaning process, thereby affecting the product yield.

This paper uses Function Analysis (FA), Cause-Effect & Contradiction Chain Analysis (CECCA), Contradiction Matrix and 40 Invention Principles. (CMIP), Parameter Deployment and Operation etc. analysis tools to analyze the engineering contradiction and physical contradiction encountered in the plasma doping process, and systematically analyze and discuss the process, expecting to find an effective solution that is over doped without reducing the production rate. We also hope to provide an empirical case of the theory of TRIZ applied to the semiconductor industry to help the industry accelerate the improvement of the problem.

1.3 Literature review

This section makes a brief literature review of the core of this paper which are divided into 2 subsections, "TRIZ Systematic Innovation Theory" and "Semiconductor Doping Process".

1.3.1 TRIZ systematic innovation theory

The so-called systemic innovation refers to the "thinking process of systematically generating innovative/creative methods to solve problems." The theory of TRIZ is part of a systemic innovation founded by the former Soviet inventor Genrich Altshuller. Altshuller has studied ten thousands of patent researches in the world and found that lots of patents can be logically integrated into a systematic and innovative thinking process. Compared with the idea of problem solving such as random or unconventional thinking, TRIZ Theory provides us with a set of traceable logic to form a solution step by step. As a result, there is a higher chance of quickly focusing on the core of the problem and shortening the time course for solving the problem.

The classical contradiction matrix (CM) and inventive principles (IPs) developed by Altshuller were based on patents from traditional industries in the 1950s. To date, no research has developed any CM and IP specifically suitable for the semiconductor industry (Sheu, D. D., Chen, C.H., 2012).

TRIZ innovative problem-solving techniques can be divided into the following processes:

A. Problem definition stage: This stage includes the formation of a project team to identify key issues and their related contradiction.

B. Solution generation stage: At this stage, the contradiction matrix in theory, Contradiction Matrix and 40 Invention Principles, parameter deployment and operation, etc. are applied to solve the problem. This stage is also the essence of the theory of TRIZ. With the above tools, there are opportunities to generate many possible answers.

C. Solution Filtering, Evaluation, and Integration stage: This stage evaluates the answers generated in the previous steps and selects the appropriate answers for implementation and evaluation. Further, this thinking process can be expanded to other areas for integration to expand the impact of systemic innovation.

1.3.2 Semiconductor doping process

Xiao, Hong (2012) said that one of the most important characteristics of semiconductor materials is that conductivity can be controlled by doping different materials, such as boron, phosphorus, nitrogen, etc. This doping process can be broadly divided into two categories: high temperature diffusion and ion implantation.

High-temperature diffusion is to provide doping atomic with kinetic energy through a high-temperature furnace to accelerate the free movement of the dopant atoms so that they have sufficient energy to impinge into the oxide layer. The design of such a process device is simple and cheaper, but the doping process time is long and the dopant concentration, impact depth and doping uniformity are not easy to control.

Ion implantation technology was first proposed by William Shockley at Bell Laboratories in 1954. It generates ions required for doping by an ion source, and the ion accelerator carries ions to carry enough energy to strike the oxide layer to complete the doping process. Compared with the high temperature diffusion method, the ion implantation can independently control the dopant concentration and depth, and the doping process time is greatly shortened.

2. Research methods

Research methods describe a series of analytical procedures for the application of the theory of TRIZ to the problem of excessive nitrogen ion doping, which is written in Section 2.1–2.3. The architecture of the entire process is shown in Figure 1.

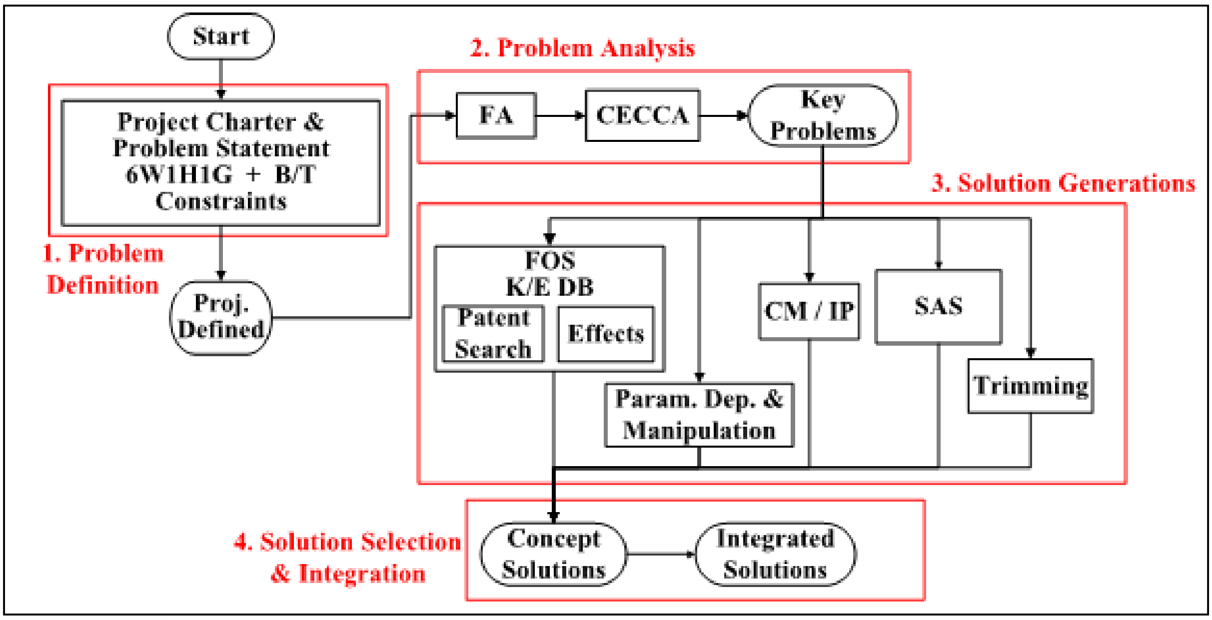


Fig. 1：Problem solving process diagram

2.1 Problem definition

With the development of semiconductor miniaturization, the use of lower energy ion implantation techniques and the need of shortening the doping time have been derived. Plasma doping technology is one of the ways to respond. Plasma doping is to introduce a doping gas (such as NH3) into a vacuum reaction chamber, and the doping gas is ionized into a plasma group with equal positive and negative charges by a radio frequency power source (RF Power). The doping ions (such as N+) are required to contact the surface of the oxide layer to complete doping. The process schematic is shown in Figure 2.

The problem in this study is that the nitrogen ion doping is excessive in the plasma doping process, which causes the photoresist to be smoothly peeled off during the subsequent cleaning process, therefore, affecting the product yield. The goal is to find a feasible solution to improve the problem of excessive doping without affecting the production rate. In this perspective, the teamwork and brainstorm behind the study gathers academic tutors, graduate student, and technical engineers.

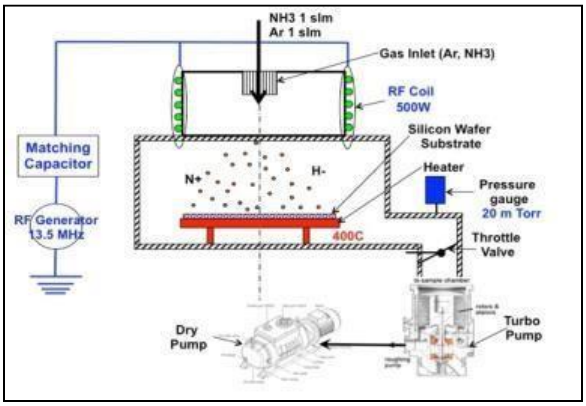


Fig. 2：Diagram of plasma doping process equipment

2.2 Method of problem analysis

First of all, from the point of view of components, we analyze the functions and interactions of all the components in the system one by one to focus on the core of the problem.

2.2.1 Method of function analysis

Function analysis is a tool for identifying problems. Through function analysis, one can understand the functions and relations between components in the system. At the same time, you can identify the functions between components are useful or negative. Usually, negative functions contain harm, excess and insufficiency. The function analysis is performed in three steps, namely component analysis, functional relationship matrix and graphic of FA. The explanation of the three steps is shown in Table 1 below.

Table 1: Function analysis table

Step	Step explanation
Component analysis	Through component analysis, the main function of the system should be identified first, and the component items included in the system and the super system should be understood to define the scope of the problem.
Functional relationship matrix	The functional relationship matrix is based on the result of component analysis. It knows all the components in the system and the operating system, and by putting each component into the functional relationship matrix, judge whether the components are in contact with each other. If two components are related, then determine whether there is a function between the components.
Graphic of FA	The graphic of FA is to complete the component analysis and functional relationship matrix, and then integrate the results into a graph, which can quickly focus on the function disadvantages, so as to make a Cause Effect Contradiction Chain Analysis later.

2.2.2 Method of Cause Effect Contradiction Chain Analysis

After the function analysis is completed, it is possible to identify the target disadvantages in the system, listing the target disadvantages in a table, and to select one or several target disadvantage points. When the target disadvantage point selection is completed, the cause effect relationship can be found through the selected target disadvantage point, and keep find until the disadvantage can't be found, and the last disadvantage point is marked as a key disadvantage point. Then, keep find the positive relationship from the key disadvantage point to the target disadvantage point. If there is a disadvantage point that has both positive and negative functions, then the disadvantage is the physical contradiction, and the relationship deduced by the physical contradiction is the engineering contradiction.

2.2.3 Families of contradiction

After the Cause Effect Contradiction Chain Analysis is completed, the physical contradiction and engineering contradiction in the system can be identified and presented by the method of "IF...THEN...BUT..." model, so-called families of contradiction. IF indicates the possibility of the solution, THEN indicates the purpose of the solution, and BUT indicates the disadvantage of the solution. Through the Families of contradiction, can make it clearer about the cause of the engineering contradiction.

2.3 Method of solution generation

At this stage, we introduce two innovative solutions which are “Contradiction Matrix and 40 Invention Principles" and " parameter deployment and operation".

2.3.1 Method of Contradiction Matrix and 40 Invention Principles

Altshuller conducted extensive research based on past patents and found that these patents can be grouped into 40 invention principles. Such as segmentation, asymmetry, nested structure, etc. Using 40 invention principles to solve the problem is to absorb the wisdom of the predecessors to solve the problem at hand. Based on problem analysis, we can use the 40 invention principles to think about possible solutions.

2.3.2 Method of parameter deployment and operation

Parameter deployment and operation is an integrated solution to solve physical contradiction in the system. Physical contradiction refers to the requirement of two contradictions for the same parameter of the same system. Firstly, it is judged whether the problem can be solved by the separation conflict requirement, and the problem is solved by the order of space, time, association, and system separation (Sheu, D. D. and Li, H. C., 2014). For example, the customer wants the smart phone screen to be large and easy to read, but still hopes that the screen is small enough to be portable. Here, the customer has a contradiction for the size (i.e. parameters) of the smartphone screen, which is a physical contradiction. To solve physical contradiction, the relevant parameters influencing, or affecting, the two objectives O1 and O2 or the contradictory parameter P need to be investigated (Sheu, D. Daniel and Rachel Yeh, 2018).

Parameter deployment helps us to start from the problem point, find the relevant components and parameters of the problem point, and clarify the parameters that may be used to solve the problem. Parameter operation solves the problem by changing various parameters. The parameter operation can be divided into three categories: "parameter domination", "parameter separation" and "parameter transfer". The difference is that "parameter separation" uses the parameters around the problem point to solve the problem, while "parameter transfer" may solve the problem with external parameters that appear to be unrelated to the problem.

The method of parameter deployment and parameter manipulation (Parameter domination and Parameter separation) can help user to perform different problem solving strategies

(PD/CPS/COPE/COEP/COEE), and propose more and more comprehensive solutions to improve the problem-solving performance of the company (Cheng, Chi-Ying and D. Daniel Sheu, 2018). Once the parameter deployment is complete, the tool can be manipulated with parameters to generate a variety of possible solutions. Figure 3 is the architecture diagram of summarizes the strategies in the parameter operation.

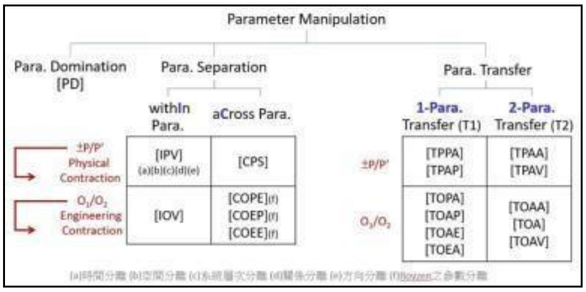


Fig. 3: Overview of the parameter operation problem solving

Following a series of detail of acronyms of the strategies (Sheu, D. D., 2015) are summarized and explain in Table 2.

Table 2. List of the various strategies

PD	**P**arameter **D**omination. By enhancing one or multiple compatible constituent parameters (Z_k) greatly to the extent that the influence by Z_k dominate the influence of P_j thus O1 and O2 can be achieved simultaneously.
IPV	With**I**n **P**arameter separation by **V**alue range. This includes all existing separation principles and more as indicated by separation at different value range of X_{jm} in Eq. 2.
CPS	**C**ross **P**arameter separation by **S**plitting parameter. Splitting a contradictory parameter into two
COPE/ COEP	**C**ross **P**arameter separation. PE: Use +P to satisfy O1 and Exclusive parameter of O2 to satisfy O2. EP: Use -P to satisfy O2 and Exclusive parameter of O1 to satisfy O1.
TPPA/ TPAP	**T**ransfer a parameter to satisfy a contradictory parameter **P**. **PA**: Let P = +P and use an Additional (external) parameter to satisfy –P. AP: Let P = -P and use an Additional (external) parameter to satisfy +P.
TOPA/ TOAP	TOPA: **T**ransfer satisfaction of **O**2 to an **A**dditional parameter while letting **P = +P** to satisfy O1. TOAP: **T**ransfer satisfaction of **O**1 to an **A**dditional parameter while letting **P = -P** to satisfy O2.
TOAE/ TOEA	TOAE: Using **E**xclusive parameter of **O**2 to satisfy O2 and **T**ransfer satisfaction of O1 to an **A**dditional parameter. TOEA: Using **E**xclusive parameter of **O**1 to satisfy O1 and **T**ransfer satisfaction of O2 to an **A**dditional parameter.
TOAA/ TOA/TOAV	Transfer satisfaction of O1/O2 (TO) to: 1) two distinct Additional parameters (AA), 2) one Additional parameter on which the contradiction disappear or become non-effectual, 3) one **A**dditional parameter but separate them by **V**alue range (AV).

3. Research Results

Research results describe the result from research method. Section 3.1 introduces the result of problem analysis, Section 3.2 describes the result of answer generation, and Section 3.3 describes the solution selection and integration.

3.1 Result of problem analysis

This section describes the result of problem analysis. Subsection 3.1.1 introduces the result of function analysis, and Subsection 3.1.2 describes the result of Cause Effect Contradiction Chain Analysis.

3.1.1 Result of function analysis

Through component analysis, the main function of the system should be identified first. The plasma doping process discussed in this study consists of a wafer substrate, an oxide layer, a plasma cluster, a heater, a vacuum pump, a reaction chamber, a pressure regulating valve, a radio frequency power, a paired capacitor, and a pressure gauge.

After the component analysis, the functional relationship matrix is based on the result of component analysis. Next, we put each component into the functional relationship matrix to judge whether the components are in contact with each other. At last, integrating the results into a graph (Figure 4), which can quickly focus on the function disadvantages

By analyzing the interactions of components in the system from the perspective of components, we are able to identify the core of the problem and focus on the contradiction points of the problem.

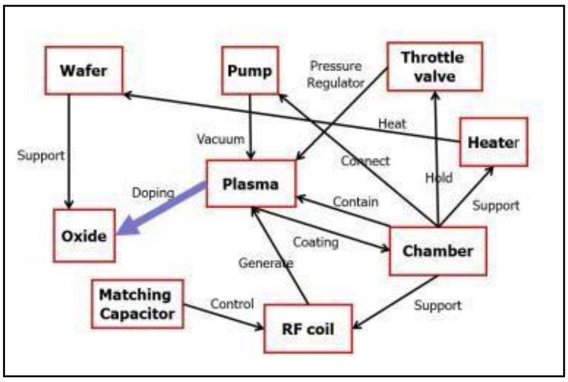


Fig. 4: Functional Attribute Analysis Chart

3.1.2 Result of Cause Effect Contradiction Chain Analysis

Through Cause Effect Contradiction Chain Analysis, we can identify the most important key disadvantage point, and Cause Effect Contradiction Chain Analysis as shown in Figure 5.

As shown in the Figure 5, we start by looking for the cause from the target disadvantages. We can find “High plasma density” combine “High oxide reactivity” are the reason cause the “High plasma N^{+}”.”High gas flow rate of NH_3” and “Low chamber pressure” and “High RF power” cause “High plasma density”. At last, since we can’t find the result of “High RF power”, we take it as the key disadvantage.

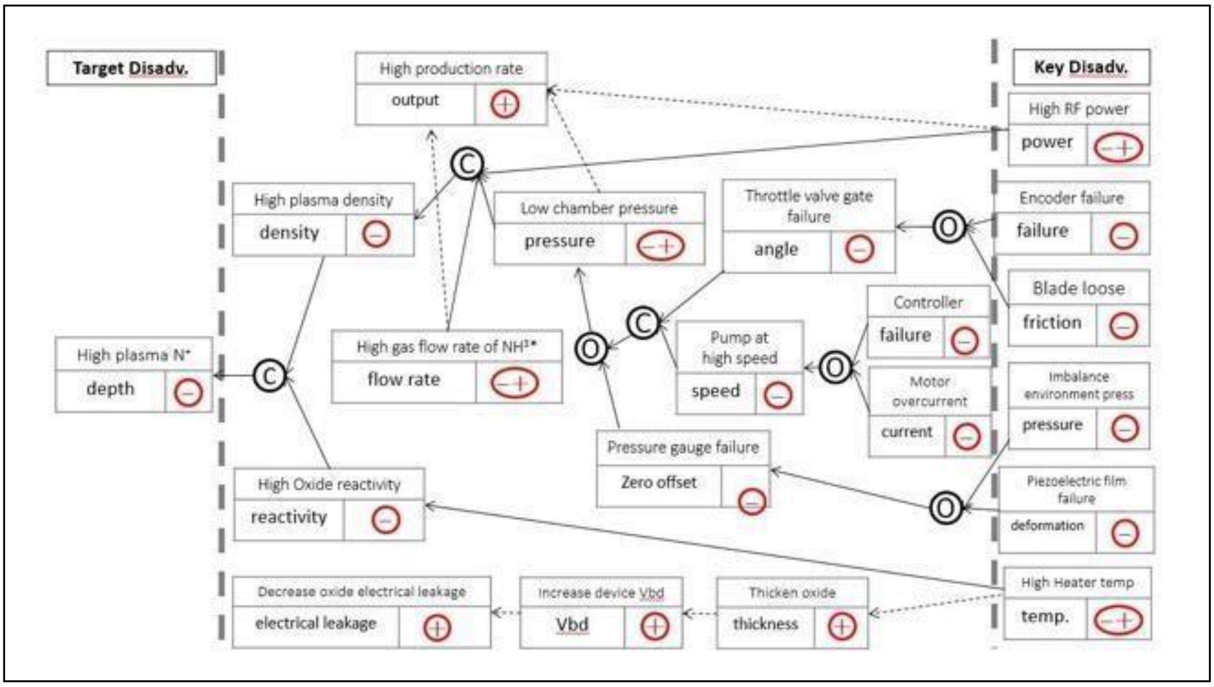


Fig. 5: Cause Effect Contradiction Chain Analysis

3.2 Result of answer generation

At this stage, we apply two innovative solutions, which are "Contradiction Matrix and 40 Invention Principles" and " parameter deployment and operation" into our case. The process is described in the following subsection 3.2.1-3.2.2.

3.2.1 Result of Contradiction Matrix and 40 Invention Principles

In this study, the plasma concentration was reduced to reach the target of excessive doping, and the radio frequency power was reduced as a means to generate a collision matrix.

The improvement parameters listed here are the loss of matter and the deterioration parameter is productivity. Based on the 40 invention principles, we can find the principles of "mechanical system replacement", "parameter change", "feedback". Guided by these inventive principles, this study proposes four possible solutions, presented in tabular form in Table 3, with schematic views of Figures 6-9.

Table 3: Answer sheet generated using 40 invention principles

40 invention principles	Innovation solution
(28) Mechanical system replacement	The plasma diffusion is replaced by a thermal diffusion method. As shown in Figure 6
(35) Parameter change	An inert gas (such as helium He) is mixed into the ammonia (NH3) to reduce the doping plasma concentration. As shown in Figure 7
(23) Feedback	The surface of the oxide layer is irradiated with ultraviolet rays, and the change in reflectance is detected as a monitoring index of the doping concentration. As shown in Figure 8
(23) Feedback	The conductive device is mounted around the wafer substrate, and the doping concentration is monitored by detecting the current generated by the ion ground. As shown in Figure 9

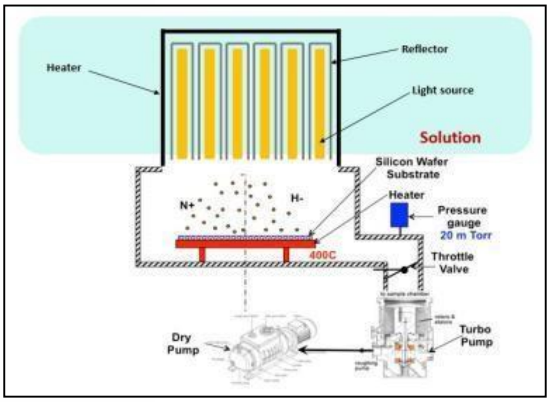


Fig. 6: Using thermal diffusion to replace plasma doping

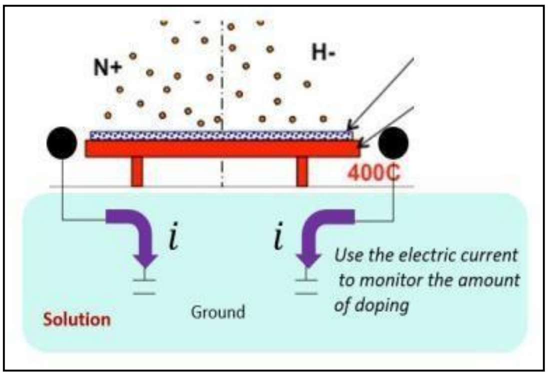


Fig. 9: Current monitoring doping concentration generated by detecting plasma grounding

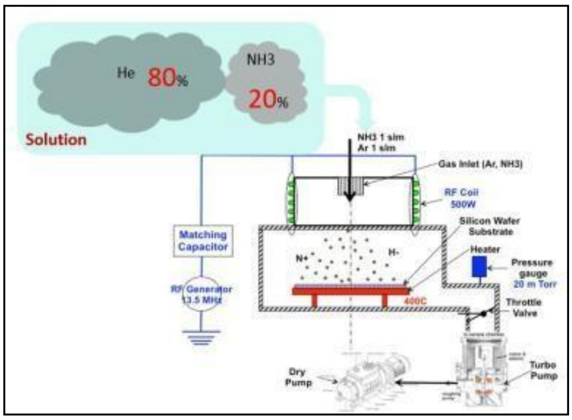


Fig. 7: Mixing inert gas to reduce plasma concentration

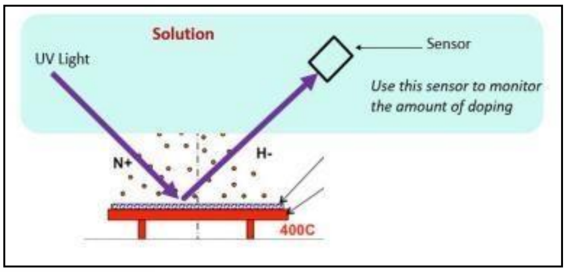


Fig. 8: Monitoring the doping concentration using UV light

3.2.2 Result of parameter deployment and operation

In this step, we first deploy the parameters, list the local system of the problem, and identify the surrounding components and related parameters, as shown in Figure 10.

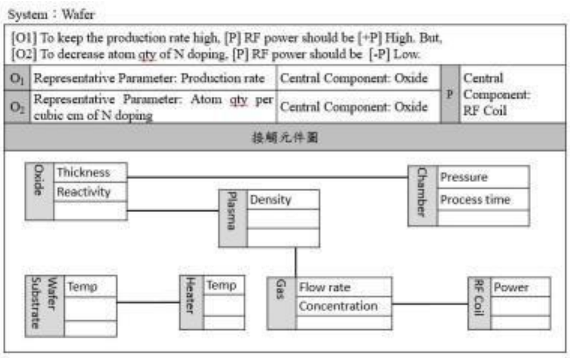
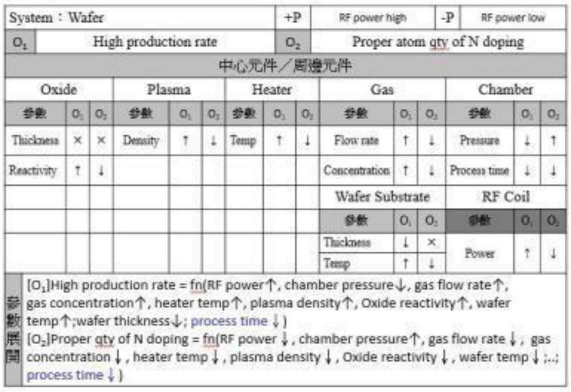


Fig. 10: Diagram of component identification

The object 1(The following is called "O1") is “High productivity”, object 2(The following is called "O2") is “Reduce the doping depth”, and the contradiction parameter is the radio frequency power. In order to meet the O1, we hope that the radio frequency power is large, but on the other hand, in order to meet the O2, we also hope that the radio frequency power is small. In order to resolve this contradiction, the parameters can be deployed after the local system is identified, as shown in Figure 11. By parameter deployment table, we can quickly focus on the parameters that can be used to solve the problem. The parameters can be classified into three categories, namely contradiction parameters, exclusive parameters and compatible parameters.



System：Wafer						+P	RF power high			-P	RF power low			
O_1	High production rate					O_2	Proper atom qty of N doping							
中心元件／周邊元件														
Oxide			Plasma			Heater			Gas			Chamber		
參數	O_1	O_2	參數	O_1	O_2	參數	O_1	O_2	參數	O_1	O_2	參數	O_1	O_2
Thickness	×	×	Density	↑	↓	Temp	↑	↓	Flow rate	↑	↓	Pressure	↓	↑
Reactivity	↑	↓							Concentration	↑	↓	Process time	↓	↓
									Wafer Substrate			RF Coil		
									參數	O_1	O_2	參數	O_1	O_2
									Thickness	↓	×	Power	↑	↓
									Temp	↑	↓			

參數展開
[O_1]High production rate = fn(RF power↑, chamber pressure↓, gas flow rate↑, gas concentration↑, heater temp↑, plasma density↑, Oxide reactivity↑, wafer temp↑;wafer thickness↓; process time↓)
[O_2]Proper qty of N doping = fn(RF power↓, chamber pressure↑, gas flow rate↓, gas concentration↓, heater temp↓, plasma density↓, Oxide reactivity↓, wafer temp↓;..; process time↓)

Fig. 11: Diagram of parameter deployment

Once parameter deployment is complete, the tool can be manipulated with parameters to generate a variety of possible solutions. Table 4 summarizes the various possible problem-solving combinations in the parameter operation. With a series of questions and thoughts in Table 4, we can systematically find possible solutions to the problem.

Table 4: Innovative solutions generated using parametric operations

strategy	solution
TOEA	Thermal diffusion doping instead of plasma doping- the use of a high temperature lamp rapidly heats the gas, allowing the gas to diffuse freely to dope the oxide layer. See Figure 6.
TOA	Change gas concentration- Inert gas (such as helium) is mixed with ammonia gas to change the plasma concentration. See Figure 7.
PD	Reduce process time-O1: High Productivity, O2: Reduce Doping Depth. By decreasing the doping process time, both O1 and O2 are satisfied.
IPV	RF power decreases by time-Rapidly increase RF power at the beginning of the process, and decrease gradually as the process progresses to mid-range. See Figure 12.
CPS	Strengthen chamber insulation-Leakage currents are prevented from entering the chamber to create additional electromagnetic fields that affect the plasma concentration. See Figure 13.
COEP	Use thinner oxide layers- using a thinner oxide layer to meet O1, and lower RF power to meet O2.
TOPA	Using sensors to monitor doping depth-dynamically control the power of wireless RF power. See Figure 8, 9.
	Increase the angle of wafer base-Using high RF power to meet O1 (high productivity) and meet O2 by adjusting the angle of the wafer base (reducing doping depth). See Figure 14.
	External electric field-Apply a new electric field around the chamber or on the bottom of the wafer. See Figure 15.
	The use of the slide rail let the RF power adjust the angle, which in turn affects the plasma concentration to meet the O2 (reduced doping depth). See Figure 16.
	Using a rotatable wafer pedestal, multiple wafers are placed in the chamber to meet O1 (high productivity), reduced RF power to meet O2 (reduced doping depth). See Figure 17.
TOAP	Multiple inlet air-change the original single inlet to multiple inlet. See Figure 18.
	A magnetic field controller will be added to change the state of the plasma flow to meet the O1 (high productivity), and the reduced radio frequency power to meet the

	O2 (reduced doping depth). See Figure 19.
	Use light heater-The use of lamp-heated heating rapidly increases the temperature. See Figure 20.
	Preheat ammonia-Pre-heat ammonia to meet O1 and O2. See Figure 21.
	Increase plasma guidance channel-add a plasma guide channel in the chamber to meet O1 and O2. See figure 22.
	Increase vacuum pump-increase vacuum pumping and speed up chamber decompression to meet O1 and O2. See Figure 23.
TOA	Composite materials-using composite materials to meet O1 and O2. See Figure 24.
	Elevating wafer base-using a vertically movable wafer base to meet O1 and O2. See figure 25.
Trimming	Trim the rotary pressure control valve with high failure rate and replace it with a higher pressure control device. See Figure 26.
TPPA	RF power pulse mode-using a capacitor divider to adjust RF power from continuous mode to pulse mode. See Figure 27.

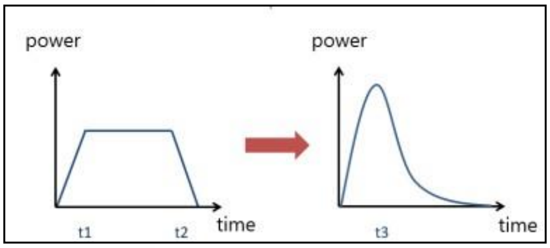


Fig. 12: Diagram of strategy IPV

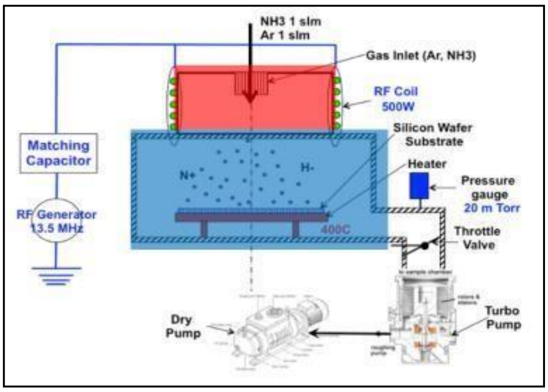


Fig. 13: Diagram of strategy CPS

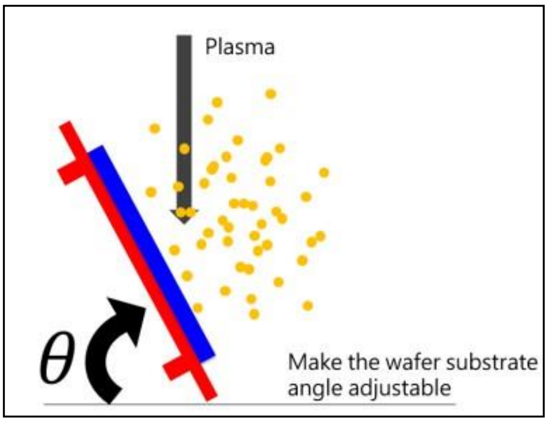


Fig. 14: Diagram of strategy TOPA (1)

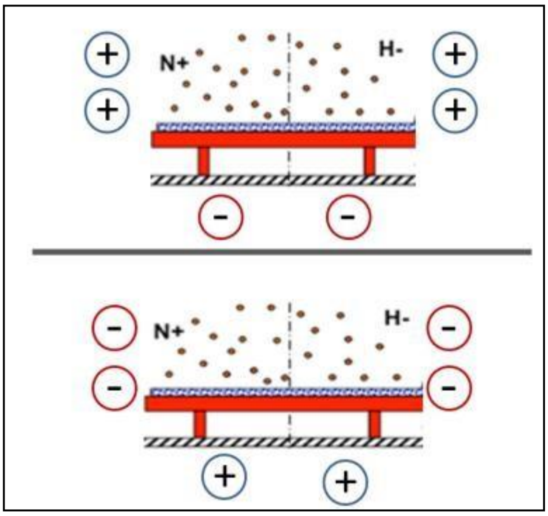


Fig. 15: Diagram of strategy TOPA (2)

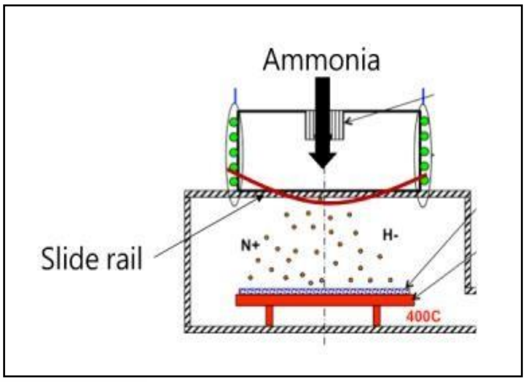


Fig. 16: Diagram of strategy TOPA (3)

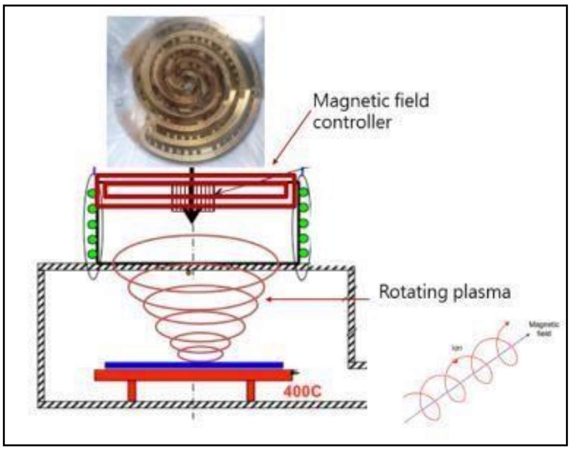


Fig. 19: Diagram of strategy TOAP (2)

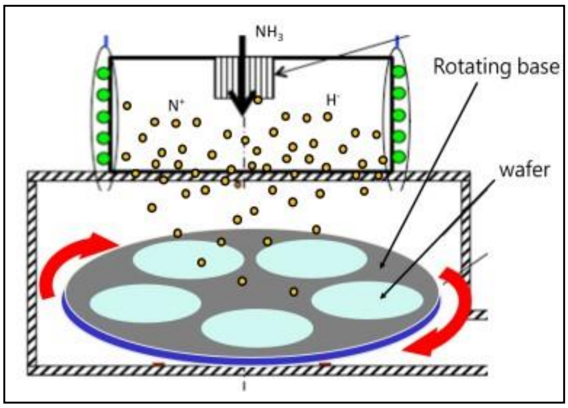


Fig. 17: Diagram of strategy TOPA(4)

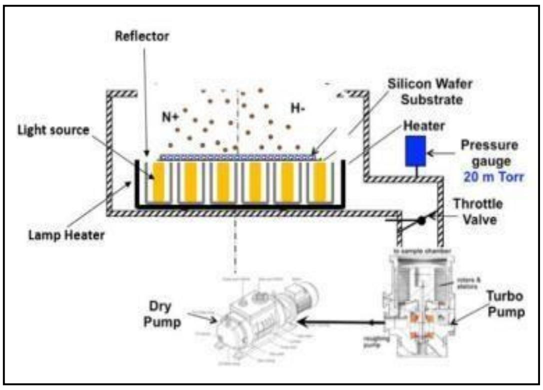


Fig. 20: Diagram of strategy TOAP(3)

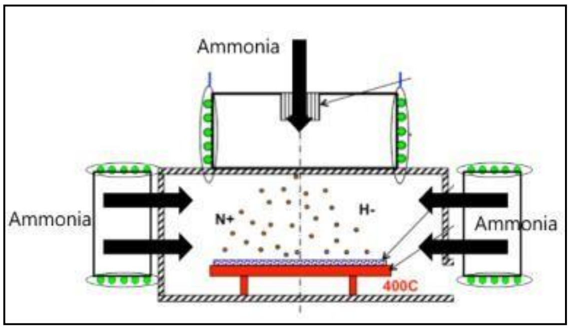


Fig. 18: Diagram of strategy TOAP(1)

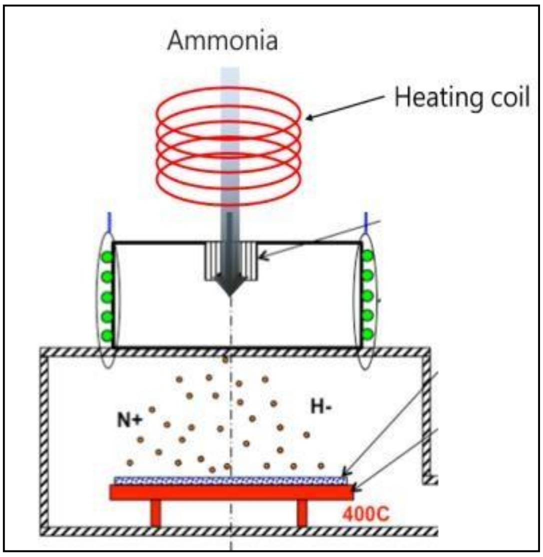


Fig. 21: Diagram of strategy TOAP(4)

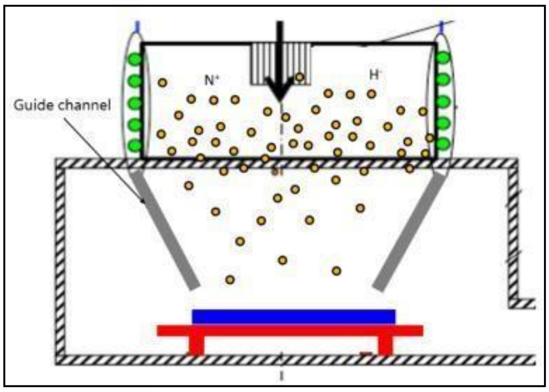


Fig. 22: Diagram of strategy TOAP (5)

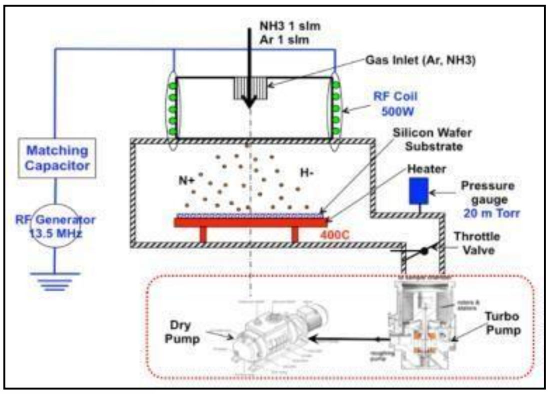


Fig. 23: Diagram of strategy TOAP (6)

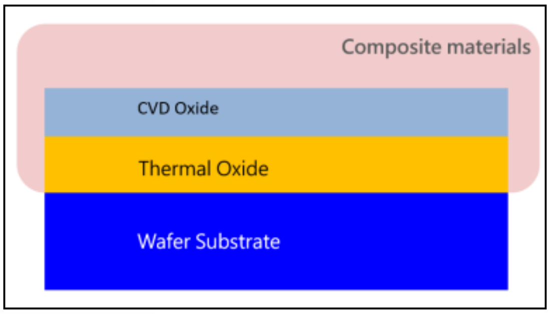


Fig. 24: Diagram of strategy TOA (1)

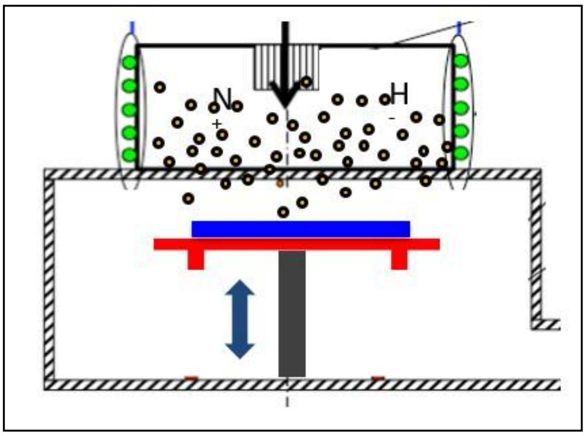


Fig. 25: Diagram of strategy TOA (2)

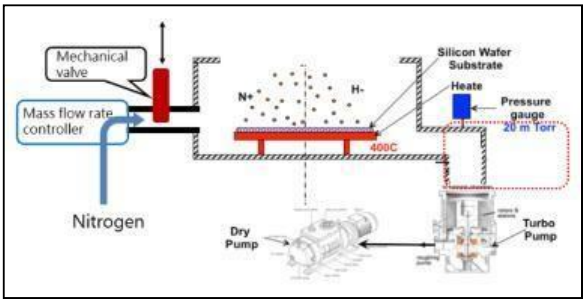


Fig. 26: Diagram of strategy trimming

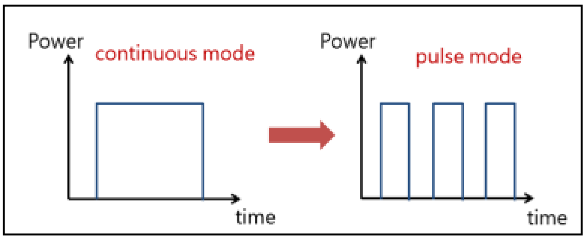


Fig. 27: Diagram of strategy TPPA

3.3 Solution selection and integration

After using different tools in the solution generation phase, we are able to come up with possible solutions based on a series of logical thinking processes and aids. In the stage of answering selection and integration, this study evaluates the feasibility and benefits of various solutions with the expertise and experience of senior technical engineers in the semiconductor industry. Finally, the "radio frequency power source pulse mode" solution generated by the TPPA problem-solving strategy in the "parameter deployment and operation" thinking process is selected and experimentally designed to verify if this solution helps to improve the excessive nitrogen ion doping. The research results are summarized in Chapter 4.

4. Summary and conclusions

This research used the theory of TRIZ systemic innovation to gradually focus on the core of the problem through a series of logical thinking processes and auxiliary tools in the process of problem definition, analysis and solution generation, resulting in more than 20 possible solutions. Compared with the traditional randomized problem-solving process, TRIZ Theory really helps us to shorten the process of solving problems. In the course of the research, the discussion and creative thinking of the project team was described as "a kind of grasping the standard of the sky and approaching the core of the problem."

In this case study, we selected the "radio frequency power source pulse mode" solution for verification. The experimental design was carried out by a well-known domestic semiconductor manufacturer, and the data was collected for analysis to test how it would help to improve the excessive nitrogen ion doping. However, due to business confidentiality, this article only briefly extracts the experimental results. It has been experimentally verified that by adjusting the time-varying rate of the wireless RF power source from the original continuous operation mode to the pulse mode, the performance index of 20% nitrogen ion doping excess is effectively reduced, and the result shows that this solution is a feasible strategy.

TRIZ Theory has been deeply integrated and summarized the wisdom of past people into a systematic study. At each stage of the problem-solving, there are a series of mature tools that help us to focus on the core of the problem. This study applied the theory of TRIZ to the improvement of nitrogen ion doping excess in the semiconductor industry. It has been proved by experiments that this systematic solution to problems does help to improve the problem. It is a mature and effective tool for solving problems.

5. References

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