

Technology theme mining of integrated circuit manufacturing industry chain based on patents

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Abstract. Excavate and compare the technical themes of IC manufacturing industry chain of domestic and foreign patents, so as to objectively and comprehensively reveal the technical themes and differences of IC manufacturing in domestic and foreign, hoping to provide valuable reference for domestic IC manufacturing. Based on the integrated circuit manufacturing process, established the patent retrieval formula of each process and retrieved the patent data. Through TF-IDF algorithm and LDA model to mine the technical topics of domestic and foreign patents on the basis of self-built thesaurus and stop-words list, and summarized mining results. Through the analysis of results, it is found that the technical topics of integrated circuit manufacturing in domestic and foreign have similarities and differences, and the upper concept is strong, but the technical topics are more detailed of foreign patents.

1 Introduction

In recent years, the development of integrated circuit industry and manufacturing technology keeps pace with the times, becomes more and more important in the security and economic construction of all countries in the world, and has become a basic, strategic and leading industry to support economic and social development and ensure national security [1]. Integrated circuits are known as modern "industrial food"[2]. Countries all over the world are "wrestling" for dominance in all links of integrated circuit industry and manufacturing technology. Integrated circuit industry and manufacturing technology have gradually become the embodiment of a country's comprehensive strength.

In the information age, integrated circuits are widely used in mobile phones, computers, communications, military, automobiles, high-speed railways, aircraft and other fields. With the development of integrated circuits, especially VLSI, the information age has developed rapidly; The rapid development of the information age continues to stimulate the strong needs of national economic informatization, national information security, national consumer electronics, military electronics and the transformation of traditional industries, so that the integrated circuit industry maintains the momentum of sustainable development and progress. The complete integrated circuit industry covers three modules: materials and equipment, manufacturing and application, as shown in Fig. 1.

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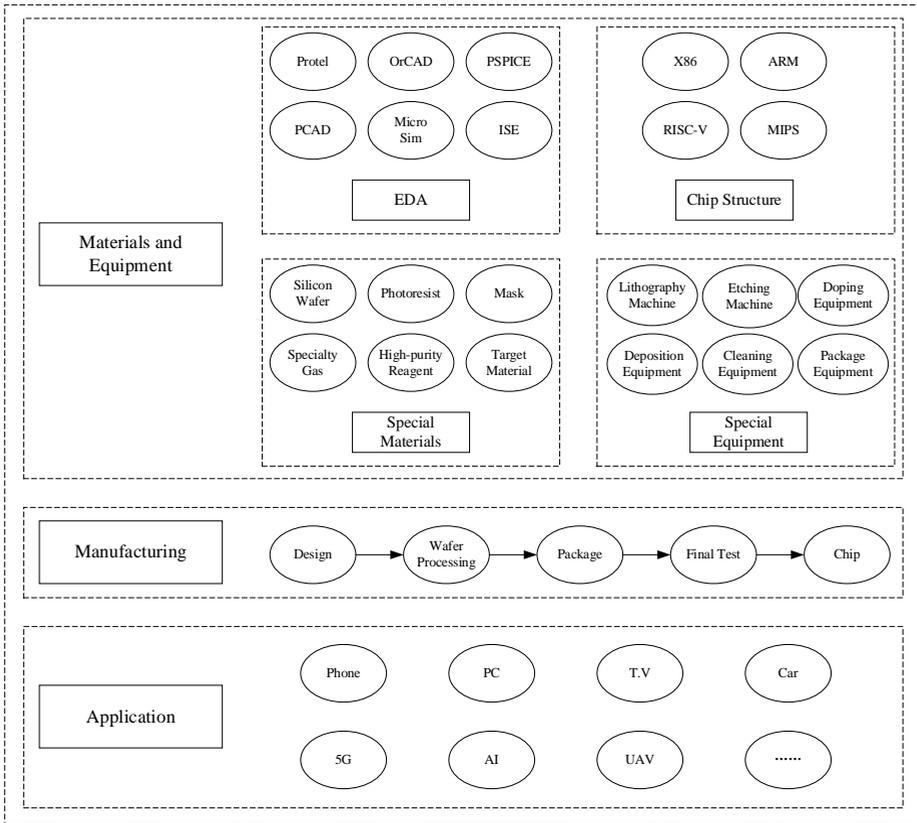


Fig. 1. Three modules of integrated circuit industry.

2 Analysis of IC manufacturing industry chain

Since Moore's law was put forward, the development of integrated circuit industry has basically followed Moore's law, that is, the integration and performance of integrated circuits will be doubled and the cost will be reduced by half every 18-24 months [3]. The characteristics of IC manufacturing industry mainly include the following five points:

- 1) There are many and miscellaneous special materials and equipment, and the industrial chain involves many enterprises.
- 2) Technology intensive and highly relevant, with large demand for talents and funds.
- 3) "Matthew effect" is significant, the concentration is higher and higher, and gradually form a monopoly.
- 4) The stability of the industrial chain is poor and there are many influencing factors.
- 5) "Moore's law" is slowing down, and the "post Moore era" is approaching.

3 Technology topic mining of IC manufacturing industry chain based on TF-IDF algorithm and LDA topic model

3.1 Data download and cleaning

In this paper, the field of analysis is the integrated circuit field, and the integrated circuit manufacturing industry chain is divided into three links: upstream design, midstream wafer

processing and downstream packaging and testing, including nine processes: upstream design, midstream lithography, midstream etching, midstream doping, midstream film deposition, midstream cleaning, midstream testing, downstream packaging and downstream testing, as shown in Fig. 2.

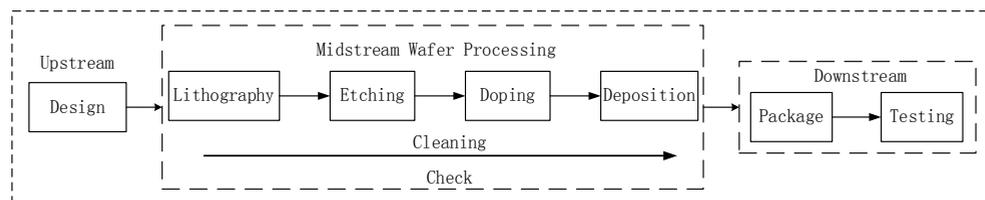


Fig. 2. Process of integrated circuit manufacturing industry chain.

According to the processes of upstream design, midstream wafer processing and downstream sealing test of the integrated circuit manufacturing industry chain shown in Fig 3.1, the patent search formula is established successively, and the search time is determined from January 1, 2010 to December 31, 2020. The selected patent database is the incompat patents database of Beijing Hexiang Zhihui Technology Co., Ltd. After patents search and data cleaning, In order to make the results of LDA[4] topic mining better, this paper first builds a thesaurus and stop list, then determines the number of topics based on the confusion index, and finally combines the perplexity value of confusion and the distribution of "topic-word", determine the optimal number of domestic and foreign patents for nine processes in the upstream, middle and downstream of this paper, as shown in table 3.1.

Table 1. Optimal number of topics for LDA topic mining.

	Design	Lithography	Etching	Doping	Deposition	Cleaning	Check	Package	Testing
Domestic	9	9	9	14	10	14	9	15	13
Foreign	11	8	10	13	13	15	8	10	12

3.2 LDA topic mining results

According to the optimal number of topics in the domestic and foreign patent text data of nine processes in the upstream, middle and downstream as shown in Table 3.1, firstly, give weight to the word segmentation results of removing stop words through TF-IDF[5] algorithm, so as to effectively filter out common words and retain words of value to each topic; Secondly, the LDA theme model is used to mine the themes of nine domestic and foreign process' patents; Finally, the "subject word" distribution is summarized, and the technical topics of each process domestic and foreign patents are obtained as follows.

1) Design: the nine technical topics of domestic patents can be summarized as RTL level logic design, optical lithography mask, failure analysis, silicon via and wiring, code transmission verification, fin FET layout, memory solution, clock tree synthesis and capacitor connection.

2) Lithography: the nine technical topics of domestic patents can be summarized as lithography original and its plate making, special materials for lithography, equipment for printing patterns on substrates, lithography patterns and cleaning solutions, substrate patterning device, objective lens device for alignment exposure of lithography machine, lithography patterning, lithography projection exposure, projection and position detection device and equipment.

3) Etching: the nine technical topics of domestic patents can be summarized as thin film transistor preparation, grooved gate structure, patterned substrate and oxide semiconductor preparation, packaging process related, waveguide device preparation based on SOI (silicon insulator) material, III-V compound, gallium nitride based light emitting diode chip, carbon nanotube and plasma etching.

4) Doping: the fourteen technical topics of domestic patents can be summarized as vapor phase epitaxy doping method and device, trench isolation structure, PN junction, image sensor with doped semiconductor materials, metal gate structure, doping of MOS devices, metal thin film, preparation of storage cells, silicon via wiring, diamond based substrate, preparation of pixel cell trenches, metal phase transition, dielectric constant Nanowire detection and chip testing.

5) Deposition: the ten technical topics of domestic patents can be summarized as Mom capacitor preparation, ZnO graphene film, nitride film, MOCVD film preparation, graphene catalyst, graphene carbon nanotube film, GaN film, components and materials related to graphene film preparation, gallium arsenide compound and plasma film deposition.

6) Cleaning: the fourteen technical topics of domestic patents can be summarized as cleaner for UV light source lithography, wafer cleaning and detection device for etching, preparation and cleaning of graphene and titanium dioxide film, resist cleaning and nano WO₃ film cleaning, cleaning for field effect transistor preparation, cleaning for trench ferroelectric memory preparation, cleaning for polysilicon film, reaction chamber cleaning device, cleaning for GaN and ZnO film growth, wafer surface photoresist cleaning device, MEMS process cleaning, grinding pad cleaning, cadmium sulfides photoelectric film cleaning.

7) Check: the nine technical topics of domestic patents can be summarized as optical pattern detection and measurement, system and detection parameters for nanowire measurement, detection and measurement devices (such as ellipsometer and scanning electron microscope), carbon nanotube film image measurement, optical image measurement device, pattern sample measurement, wafer image measurement, wafer defect detection device Wafer electrical test.

8) Packaging: the fifteen technical topics of domestic patents can be summarized as chip level chip level packaging, low-k etching barrier, probe and packaging testing, chip level packaging heat dissipation, TSV packaging technology, cladding chip packaging, image sensing chip packaging, system level packaging, three-dimensional packaging, silicon through-hole copper interconnection, flip chip packaging, diode packaging, TSV packaging heat dissipation related technologies Silicon via interconnect packaging technology, silicon wafer packaging, single wall and multi wall carbon nanotubes.

9) Testing: the thirteen technical topics of domestic patents can be summarized as deep submicron bipolar transistor protection, photoelectric probe, storage medium signal test, DMOS test, MOSFET test, breakdown voltage protection device GGNMOS, test software and hardware, ESD test, test protection device, test temperature control, micron test display, test station and slot, SOI test.

3.3 Summary

By summarizing the domestic and foreign patents technology topics of nine processes in the upper, middle and lower reaches of the integrated circuit manufacturing industry chain, it can be found that these technology topics have similarities and differences, and the upper concept is strong, but the foreign technology topics are relatively more detailed. Taking the design process as an example, the technical themes of domestic patents are relatively scattered, but the superior concepts of these technical themes are strong. The technical theme of foreign layout patents pays more attention to the direction of signal, layout, clock

tree and memory. The layout can affect the final area of integrated circuit, and the signal of clock tree can play a leading role in the overall situation of digital integrated circuit. Memory is the leading field of integrated circuit market.

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