

# 3D Non-Volatile Memory

## Patent Landscape Analysis – March 2018

*The 3D Non-Volatile Memory field is changing fast.  
How the Chinese players can find a place in a crowded space?*

### REPORT OUTLINE

- 3D Non-Volatile Memory
- Patent Landscape Analysis
- March 2018
- PDF > 150 slides
- Excel file > 3,400 patents
- €6,490 for a corporate license
- Ref.: KM18003



### KEY FEATURES OF THIS REPORT

- **IP trends**, including time evolution of published patents and countries of patent filings.
- **Current legal status** of patents.
- Ranking of **main patent assignees**, their patented technologies, joint developments and IP partnerships.
- **Key patents** and granted patents near expiration.
- **IP position of key players**, and relative **strength** of their patent portfolios.
- **IP profiles** for 6 major companies: SanDisk/Western Digital, Micron Technology, SK Hynix, Toshiba, Samsung, Macronix International.
- **Key Patents** related to 3D NAND devices of key companies: trend of patent publications in China
- IP Analysis of 3D non-volatile memory **types** and **configurations**.
- Focus on **3D XPoint Memory**.
- **Excel database** with all patents analyzed in the report, including technology segmentation.

### RELATED REPORTS

- [TSV Stacked Memory Patent Landscape 2016](#) (Knowmade)
- [Resistive Memory Patent Landscape 2015](#) (Knowmade)
- [Emerging Non-Volatile Memory 2017](#) (Yole Développement)

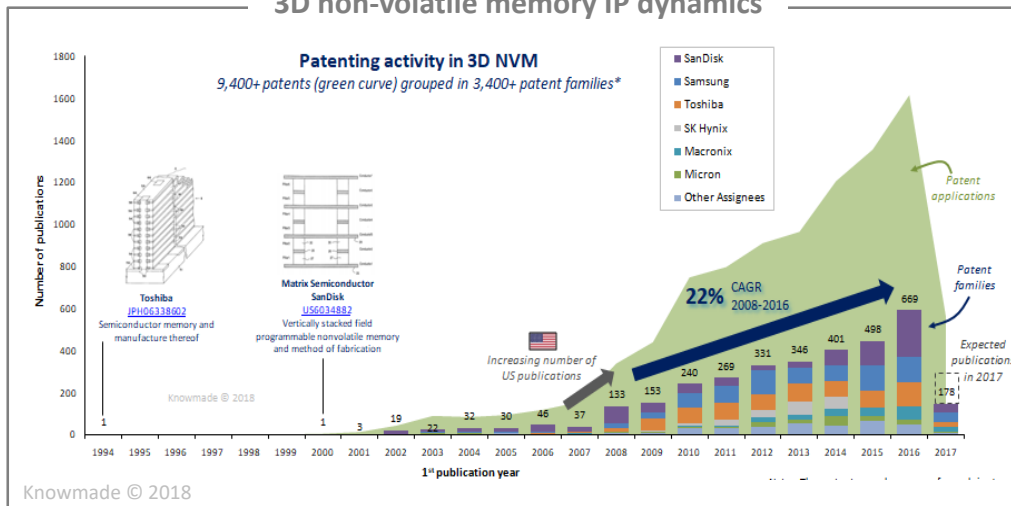
### A YOUNG MARKET WITH BIG PLAYERS AND A FAST-MOVING IP LANDSCAPE

**3D NAND Flash** Memory devices appeared on the market in 2015 with **3D V-NAND – 32L** of Samsung Electronics, followed in 2016 with **3D NAND V2 – 36L** of SK Hynix, **3D NAND – 48L** of Toshiba/SanDisk and **3D NAND – 32L** of Micron/Intel.

In recent times, it happens a lot in the **3D non-volatile memory** (3D NVM) field with the acquisition of **SanDisk** by **Western Digital**, The investments of **Chinese government** in memory, or the Intel announcement of the **Intel/Micron** separation for further development of 3D NAND. We witnessed these evolves in the IP landscape through the recent increase of 3D NVM-related patents filed by **Chinese players** (YMTC/YRST) and the numerous **Samsung's** patents published the latest months in China, USA and Korea, reflecting its willing to strengthen its 3D NVM IP portfolio. Also, we observed **non-practicing entities** (NPEs) like Conversant IP and WiLAN are entering the landscape. The presence of such companies is a tangible sign of the market explodes, heralding **future IP battles** when they will assert their patents to make money.

In this report, KnowMade has thoroughly investigated the patents related to **3D non-volatile memories** and draws a picture of the **current patent landscape and its potential evolution**. SanDisk/Western Digital, Samsung and Toshiba are leading the 3D NVM patent landscape. They hold together more than 65% of the patents, Western Digital and Toshiba signed a JV extension until 2029, and Samsung and Western Digital renewed a patent cross-license agreement until 2024. On the other hand, we witness the emergence of Chinese players in the IP landscape.

### 3D non-volatile memory IP dynamics



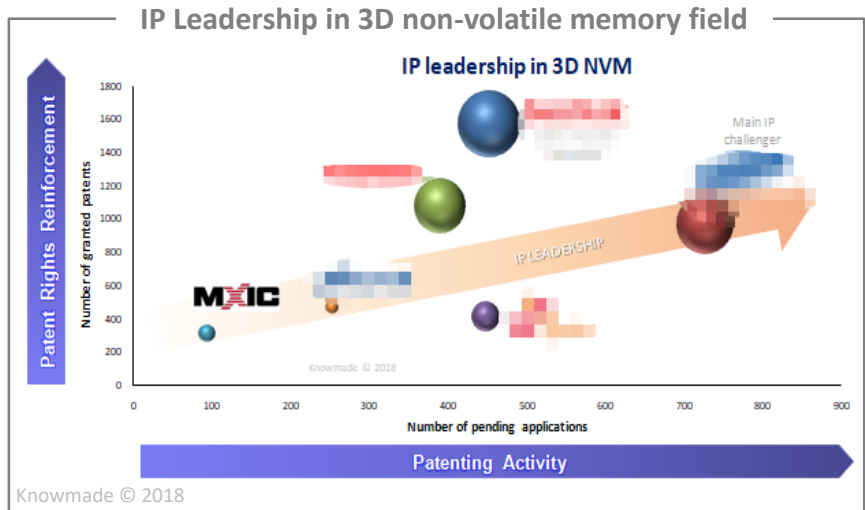
Patent activity related to 3D non-volatile memory (3D NVM) emerged in the 1990s with Toshiba and SanDisk. They signed Joint Venture agreement on Flash Memory in 1999. In the end 2000s, the research and development of 3D architectures appeared with IP related to BiCS (Bit Cost Scalable, SanDisk and Toshiba), TCAT (Terabit Cell Array Transistor, Samsung Electronics) and FG (Floating Gate, SK Hynix). Few years later Micron Technology developed also FG architecture, and Macronix International developed in 2015 SGVC architecture (Single Gate Vertical Channel). Since 2008, the number of patents related to 3D NVM has continuously increased, and today the **3D NVM patent landscape** represents over **3,400 patent families** including more than 9,400 patents. The landscape is very **competitive**, with several **big companies** and the entrance of **Chinese players** these last years.

### IDENTIFY KEY IP PLAYERS

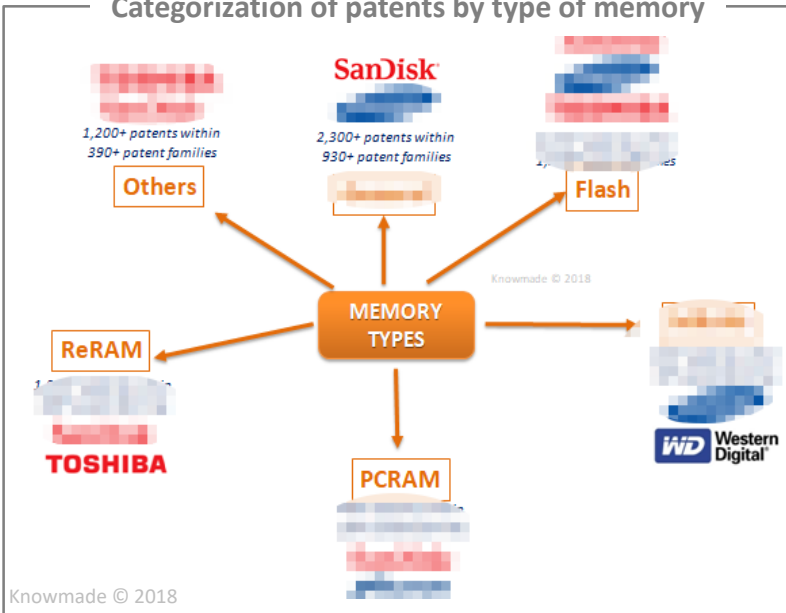
This report reveals the **relative strengths of the top patent owners** derived from their portfolio size, patent citation networks, countries of patent filings, and current legal status of patents. Through this in-depth analysis, each of 6 major **market players are profiled** in this report: SanDisk/Western Digital, Micron Technology, SK Hynix, Toshiba, Samsung, Macronix International. Each profile includes a detailed portfolio analysis with **IP dynamics, IP strategies and key patents** linked to 3D NAND products.

The 3D non-volatile memory patent landscape involves **big companies**, and this closed domain is very **difficult to enter for newcomers**. Nevertheless **Chinese companies are entering the landscape** thanks to their financial means and will maybe change the 3D NVM development of further 3D memory layers.

Note that equipment manufacturers like **Applied Materials, Tokyo Electron and Lam Research** have less than 20 patents related to a 3D non-volatile memory.



### Categorization of patents by type of memory



### IDENTIFY KEY TECHNOLOGIES

The **3,400 patent families** selected for this study have been **categorized by memory types and main architectures**.

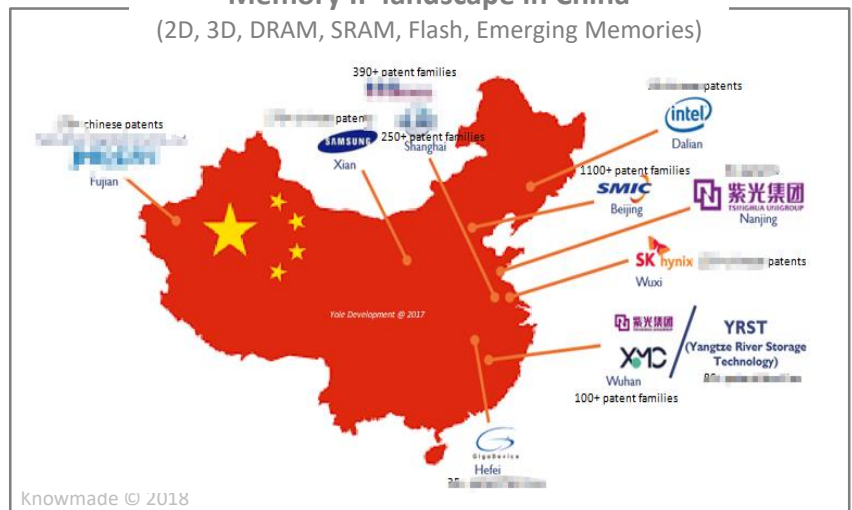
This report reveals the **IP strategy and technical choices** of patent assignees. We analyzed the current **IP position of key players** regarding the **type of memory** (Flash, MRAM, ReRAM, PCRAM) and the **architecture** (vertical, cross-point). Some companies concentrate on one memory type such as Micron Technology on PCRAM as we expect it with the research on 3D Xpoint Memory. Others like SanDisk are involved in several 3D Non-Volatile Memories.

### FOCUS ON CHINA

With all the funds invest by Chinese government in Memory, YMTC/YRST developed last year old generation 3D NAND 36L and try to catch up with major companies. However we can ask us, **where do Chinese companies get their IP ?** The China memory-related IP landscape is analyzed (2D, 3D, DRAM, SRAM, Flash, Emerging Memories) in order to understand the **IP trends and technologies owned by Chinese players** such as XMC, YRST, Tsinghua Unigroup, SMIC, etc.

We also investigated what IP do the **major companies involved in China** have like Samsung, SK Hynix or Intel.

### Memory IP landscape in China (2D, 3D, DRAM, SRAM, Flash, Emerging Memories)



### USEFUL PATENT DATABASE

This report also includes an **Excel database** containing the **>9,400 patents analyzed in this study**. This useful patent database allows **multi-criteria searches** and includes for each patent its publication numbers, the hyperlink to the original document, its priority dates, title, abstract, patent assignees, memory types/architectures, and current legal status.

**COMPANIES AND ACADEMICS CITED IN THIS REPORT (PARTIAL LIST)**

Samsung Electronics, Micron Technology, SanDisk/Western Digital, Intel, SK Hynix, Toshiba, 3D Monolithic, SMIC, United Microelectronics, Sino King Technology, YRST/YMTC (Yangtze River Storage Technology), GigaDevice, Rambus/Unity Semiconductor, etc.

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(2D, 3D, DRAM, SRAM, Flash, emerging memories)  
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**CONCLUSIONS** \_\_\_\_\_ **121****KNOWMADE COMPANY PRESENTATION** \_\_\_\_\_ **130****AUTHORS****Dr. Audrey Bastard**

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**ABOUT KNOWMADE**

Specializing in patent analysis and scientific information, **Knowmade** provides technology intelligence and IP strategy consulting services. The company supports R&D organizations, industrial companies, and investors in their business development by offering them a deep understanding of their IP environment and technology trends.

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## 3D NON-VOLATILE MEMORY

Patent Landscape Analysis – March 2018

Ref.:KM18003

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**Signature:**

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“Intellectual Property Rights” (“IPR”) means any rights held by the Seller in its Products, including any patents, trademarks, registered models, designs, copyrights, inventions, commercial secrets and know-how, technical information, company or trading names and any other intellectual property rights or similar in any part of the world, notwithstanding the fact that they have been registered or not and including any pending registration of one of the above mentioned rights.

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BIC or SWIFT code: CCBPFRPPMAR

IBAN: : FR76 1460 7003 6360 6214 5695 139

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

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