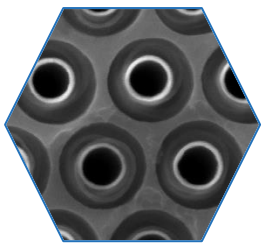
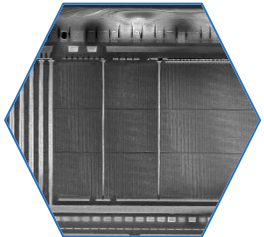


Intel 144-layer 3D NAND Memory

Intel's Quad-Level Cell 3D NAND with 144 active wordlines in three decks, with CMOS under array and floating gate technology.



Title: Intel 144-layer 3D NAND Memory

Pages: 106

Date:
November 2021

Format:
PDF & Excel file

Price:
EUR 3,990

Reference:
SPR21616

Huge volumes of data are generated daily and this data growth has created a strong demand for cost-effective, high-performance non-volatile memory. NAND revenue reached over \$56 billion dollars in 2020 and bit growth is estimated at 38% between 2020 and 2021. This could drive NAND memory revenue up to \$70 billion in 2021 according to the NAND Market Monitor, Q3 2021. Intel had a NAND market share of 9% in 2020.

The market's first-ever 144-layer triple-level cell NAND design can store up to four bits per cell (QLC). Intel's memory technology is unique, combining floating gate architecture with CMOS under array (CuA). Placing the CMOS under array allows Intel to produce 1024Gb chips with a density of over 12Gb/mm². Intel's fourth-generation 3D NAND memory stacks over 160 wordlines. Floating gate technology uses a discrete-charge storage node, which results in improved NAND cell-data retention. QLC allows more data to be stored without occupying extra area on the chip.

This 144-layer QLC NAND memory has 50% higher bit-density compared to Intel's 96-layer NAND memory. Intel continues to stack more wordlines and use QLC memory, resulting in higher storage potential while delivering more potential storage per NAND wafer at a lower

manufacturing cost.

This report includes a full analysis of the SSD teardown and memory package, accompanied by optical and high-resolution SEM images of the package and die. The die cross-section reveals Intel's three decks of alternating layers of wordlines and insulating material. The cross-section images reveal the NAND memory structure and the floating gate. EDX analysis allowing for material identification has been performed to reveal the materials used in the memory manufacturing process. Also provided in this report is the manufacturing process of Intel's 144-layer 3D NAND memory and the final package & assembly. Lastly, a cost analysis is furnished which includes an estimation of Intel's 144-layer QLC, CuA NAND memory wafer, and die.

COMPLETE TEARDOWN WITH:

- Detailed optical and SEM photos
- Precise measurements
- Materials analysis
- Manufacturing process flow
- Supply chain evaluation
- Manufacturing cost analysis
- Selling price estimation

TABLE OF CONTENTS

Introduction

- Executive Summary

Company Profile (Intel)

- Intel Financials
- Intel Products & Location
- Intel Floating Gate Technology
- 3D NAND Memories

Technology & Market Analysis

- NAND Revenue
- NAND Bit Shipment

Physical Analysis

- Intel 670p SSD Overview
- Package Views & Dimensions
- Package Opening
- Package Cross-Section
- Die Views & Dimensions
- Die Cross-Section

- Die Delayering
- Die Process & Patents

Manufacturing Process

- NAND Die Front-End Process & Fab Unit
- Assembly & Final Test

Cost Analysis

- Yields
- NAND Memory Front-End Cost
- NAND Memory Probe Test & Dicing
- NAND Wafer Cost
- NAND Die Cost
- NAND Component Cost (512GB)
- Cost per GB

Price

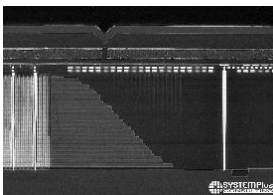
- NAND Memory Price (512GB)

AUTHOR



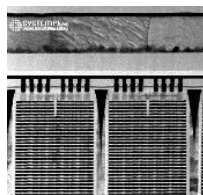
Belinda Dube is working for System Plus Consulting as an Engineer & Analyst, Semiconductor Memories, especially DRAM and 3D NAND flash memory. At the same time, she also investigates IC technologies as well as advanced packaging. Belinda is also engaged in the development of reverse engineering & costing analyses with the power electronics and compound semiconductors team.

RELATED ANALYSES



Samsung 128-layer V-NAND Memory

Samsung's 6th-generation 3D NAND TLC with 128 active wordlines in a single deck array with side peripheral logic.
November 2021 - EUR 3,990*



SK hynix 128-Layer NAND Memory

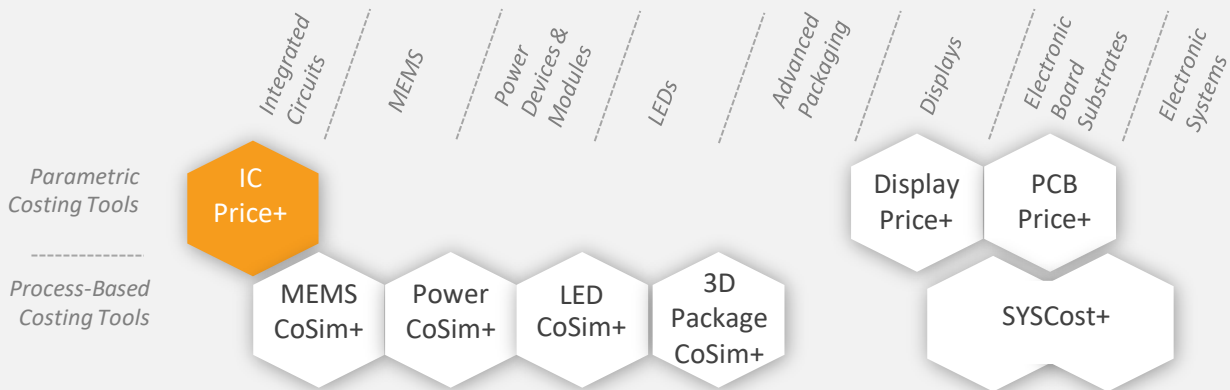
Second-generation PuC 3D NAND memory and cost comparison to 72-layer with periphery on the side.
August 2021 - EUR 3,990*



Status of the Memory Industry 2021

NAND consolidation, China's bet on two key players, the rise of the CXL interface: as the memory business narrows, the market keeps growing and is poised to exceed \$200B in 2026.
June 2021 - EUR 6,490*

COSTING TOOLS



Our analysis is performed with our costing tool IC Price+.

System Plus Consulting offers powerful costing tools to evaluate the production cost and selling price from single chip to complex structures.

IC Price+

The tool performs the necessary cost simulation of any Integrated Circuit: ASICs, microcontrollers, DSP, memories, smartpower...

ABOUT SYSTEM PLUS CONSULTING

WHAT IS A REVERSE COSTING®?

Reverse Costing® is the process of disassembling a device (or a system) in order to identify its technology and calculate its manufacturing cost, using in-house models and tools.



CONTACTS

Headquarters
 22, bd Benoni Goullin
 Nantes Biotech
 44200 Nantes
 France
 +33 2 40 18 09 16
 sales@systemplus.fr

Europe Sales Office
 Lizzie LEVENEZ
 Frankfurt am Main
 Germany
 +49 151 23 54 41 82
 lizzie.levenez@yole.fr

America Sales Office
 Hal LEVY
 Western USA & Canada
 +1 408 334 0554
 hal.levy@yole.fr

Chris YOUMAN
 Eastern USA & Canada
 +1 919-607-9839
 chris.youman@yole.fr

Asia Sales Office
 Takashi ONOZAWA
 Japan & Rest of Asia
 +81 80 4371 4887
 onozawa@yole.fr

Mavis WANG
 Greater China
 TW +886 979 336 809
 CN +8613661566824
 wang@yole.fr

Peter OK
 Korea
 +82 10 4089 0233
 peter.ok@yole.fr

System Plus Consulting is specialized in the cost analysis of electronics from semiconductor devices to electronic systems. A complete range of services and costing tools to provide in-depth production cost studies and to estimate the objective selling price of a product is available.

Our services:

- **STRUCTURE & PROCESS ANALYSES**
- **TEARDOWNS**
- **CUSTOM ANALYSES**
- **COSTING SERVICES**
- **COSTING TOOLS**
- **TRAININGS**

www.systemplus.fr
 sales@systemplus.fr

TERMS AND CONDITIONS OF SALES

1. INTRODUCTION

The present terms and conditions apply to the offers, sales and deliveries of services managed by System Plus Consulting except in the case of a particular written agreement.

Buyer must note that placing an order means an agreement without any restriction with these terms and conditions.

2. PRICES

Prices of the purchased services are those which are in force on the date the order is placed. Prices are in Euros and worked out without taxes. Consequently, the taxes and possible added costs agreed when the order is placed will be charged on these initial prices.

System Plus Consulting may change its prices whenever the company thinks it necessary. However, the company commits itself in invoicing at the prices in force on the date the order is placed.

3. REBATES and DISCOUNTS

The quoted prices already include the rebates and discounts that System Plus Consulting could have granted according to the number of orders placed by the Buyer, or other specific conditions. No discount is granted in case of early payment.

4. TERMS OF PAYMENT

System Plus Consulting delivered services are to be paid within 30 days end of month by bank transfer except in the case of a particular written agreement.

If the payment does not reach System Plus Consulting on the deadline, the Buyer has to pay System Plus Consulting a penalty for late payment the amount of which is three times the legal interest rate. The legal interest rate is the current one on the delivery date. This penalty is worked out on the unpaid invoice amount, starting from the invoice deadline. This penalty is sent without previous notice.

When payment terms are over 30 days end of month, the Buyer has to pay a deposit which amount is 10% of the total invoice amount when placing his order.

5. OWNERSHIP

System Plus Consulting remains sole owner of the delivered services until total payment of the invoice.

6. DELIVERIES

The delivery schedule on the purchase order is given for information only and cannot be strictly guaranteed. Consequently any reasonable delay in the delivery of services will not allow the buyer to claim for damages or to cancel the order.

7. ENTRUSTED GOODS SHIPMENT

The transport costs and risks are fully born by the Buyer. Should the customer wish to ensure the goods against lost or damage on the base of their real value, he must imperatively point it out to System Plus Consulting when the shipment takes place. Without any specific requirement, insurance terms for the return of goods will be the carrier current ones (reimbursement based on good weight instead of the real value).

8. FORCE MAJEURE

System Plus Consulting responsibility will not be involved in non execution or late delivery of one of its duties described in the current terms and conditions if these are the result of a force majeure case. Therefore, the force majeure includes all external event unpredictable and irresistible as defined by the article 1148 of the French Code Civil?

9. CONFIDENTIALITY

As a rule, all information handed by customers to system Plus Consulting are considered as strictly confidential. A non-disclosure agreement can be signed on demand.

10. RESPONSABILITY LIMITATION

The Buyer is responsible for the use and interpretations he makes of the reports delivered by System Plus Consulting. Consequently, System Plus Consulting responsibility can in no case be called into question for any direct or indirect damage, financial or otherwise, that may result from the use of the results of our analysis or results obtained using one of our costing tools.

11. APPLICABLE LAW

Any dispute that may arise about the interpretation or execution of the current terms and conditions shall be resolved applying the French law.

If the dispute cannot be settled out-of-court, the competent Court will be the Tribunal de Commerce de Nantes.