# NEW READ RETRY

# Powerful and automatic solution to improve reading of NAND flash chips

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### What is Read Retry?



#### READ RETRY IS A SPECIFIC COMMAND SET TO TWEAK READING MODE



### Problem with chip reading – bit errors

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### Bit error sources

- Read disturb (noise, connection problems)
- Program disturb
- Endurance of cells
- Data retention



### Error Correction Codes (ECC)



ECC CORRECTABILTY IS STRICTLY LIMITED BY ECC CAPABILITY Uncorrectable errors can be repaired with Read Retry



### NAND flash internals





### Page decoder



#### ANALOG STATES FROM CELLS ARE CONVERTED INTO DIGITAL DATA



### Architecture of cells





# Thresholds in memory cells



THE DATA IN CELL IS STORED AS A VOLTAGE LEVEL



Voltage[V] = Stored data

# Bits inside memory cell



THE DATA IN CELL IS STORED AS A VOLTAGE LEVEL Controller is reading data according to specific zones



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### **Retention Error**



#### WHEN CHARGE LEAKS OUT FROM CELL WE GET BIT ERROR



# **Read-Retry Mechanism**



Cycle	1	2	3	4	HEX
Initial	10	11	11	10	BE
Default read	00	11	11	00	<b>3C</b>

#### WHEN CHARGE LEAKS OUT FROM CELL WE GET BIT ERROR Degraded cell gives wrong data



Voltage[V] = Stored data

# Read-Retry Mechanism #1



#### **READ RETRY MECHANISM HELPS TO SHIFT READ VOLTAGE THRESHOLDS**



# Read-Retry Mechanism #2



#### **READ RETRY MECHANISM HELPS TO SHIFT READ VOLTAGE THRESHOLDS**



### Sets of parameters



ALL ZONES NEED TO BE ADJUSTED SEPARETLY



# Read Retry effect





DIFFERENT PARAMETERS PRODUCE DIFFERENT ERROR RATE



# What we did to implement Read Retry?

New firmware which allows us to read chips faster and change NAND protocol instantly





### We made new universal software platform just to start Read Retry analysis

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34.00	27.00	33.00	30.00	37.00	42.00	33.00	31.00			
38.00	27.00	41.00	39.00	39.00	49.00	36.00	37.00			
37.00	34.00	47.00	37.00	43.00	54.00	40.00	43.00			
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### More than 500 devices analyzed **TO UNDERSTAND** what controller does to improve reading





### And finally after ~2000 human hours we made an automatic and smart Read Retry algorithm in VNR

Testing Read Retry... Read Retry is found and applied Pass 1 Error blocks count: 87 Corrected blocks: 49 Not corrected blocks: 38 \_\_\_\_\_ Testing Read Retry... Read Retry is found and applied Pass 2 Error blocks count: 38 Corrected blocks: 0 Not corrected blocks: 38 Testing Read Retry... Read Retry is found and applied Pass 3 Error blocks count: 38 Corrected blocks: 35 Not corrected blocks: 3



### Read Retry results compared to normal ECC ReRead

#### **Effectiveness of correction**



**READ RETRY HELPS TO CORRECT ERRORS FROM ANY SOURCE** When ReRead corrects errors caused only by read disturb



### Already supported chips





#### **MUCH MORE SOON**

# SUMMARY

- READING NAND FLASH WITH READ RETRY HELPS TO ADJUST READING PROTOCOL AND SIGNIFICANTLY IMPROVE ٠ **QUALITY OF DATA**
- ALL NEW CHIPS HAVE A BUILT-IN READ RETRY MECHANISM AND ITS USAGE IS THE ONLY PROPER WAY TO ٠ **EXTRACT PHYSICAL IMAGE**
- WORKING BETA VERSION IS RELEASED IN VNR 3.5. ٠
- IN CURRENT VERSION OF SOFTWARE IT IS SPECIFICALLY DESIGNED FOR PARTICULAR MEMORY CHIP ٠

IT IS A AVAILABLE BY REQUEST AT: SUPPORT@RUSOLUT.COM

### LET'S MOVE TO PRACTICAL PART

