

# 李乔

厦门大学信息学院副教授

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## 教育背景

博士, 计算机科学, 香港城市大学 2017.09 - 2021.07  
导师: 薛春教授, 郭大维院长

学术型硕士, 计算机科学与技术, 重庆大学 2014.09 - 2017.07  
导师: 诸葛晴凤教授, 石亮教授

学士, 信息安全, 重庆大学 2010.09 - 2014.07

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## 工作经历

副教授, 厦门大学信息学院 2022.02 - 至今

博士后, 香港城市大学 2021.08 - 2022.02

科研助理, 香港城市大学 2020.09 - 2021.07

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## 获奖情况

HotStorage 2021 最佳论文奖 (1/15) 2021 年

获奖论文: **Qiao Li**, Min Ye, Tei-Wei Kuo, Chun Jason Xue. How the common retention acceleration method of 3D NAND flash memory goes wrong?

香港城市大学优秀学业表现奖 (<25%) 2019 年及 2018 年  
Outstanding Academic Performance Award, City University of Hong Kong

香港城市大学学费奖学金 (<20%) 2019 年及 2018 年  
Research Tuition Scholarship, City University of Hong Kong

“阿里云-中国计算机学会存储专委会”优秀论文奖 2019 年  
获奖论文: **Qiao Li**, Liang Shi, Jun Yang, Youtao Zhang, Chun Jason Xue: Leveraging Approximate Data for Robust Flash Storage.

ASP-DAC 2017 最佳论文提名奖 (11/111) 2017 年  
获奖论文: **Qiao Li**, Liang Shi, Chun Jason Xue, Qingfeng Zhuge, Edwin Hsing-Mean Sha: Improving LDPC performance via asymmetric sensing level placement on flash memory.

重庆大学海云天大数据奖学金 2016 年

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## 学术研究/项目经历

主要学术贡献与创新：

- 一、 新一代存储可靠性研究：针对闪存可靠性下降引发的闪存性能及寿命瓶颈问题，我的主要研究工作有：针对多款真实闪存芯片，提出了多种错误测试的实验方法，发现了现有保存时间错误估计方法中存在的问题，提出了一种基于错误发生机制和特征的纠错码设计，提高了闪存可靠性，这些工作为后续的研究提供了基础（HotStorage, ASP-DAC, ICCD, TC, TR）
- 二、 高性能固态存储技术：从底层存储读写操作特性到上层数据访问特性等多个角度出发，提出并设计了高密度固态存储性能优化算法，包括基于电压偏移的重读机制的改善设计，基于数据访问特征的读写处理策略和寿命优化算法，基于数据压缩后回填对齐的数据访问性能提升机制（FAST, MICRO, ICCD, TC）
- 三、 存储系统数据布局优化方法：根据数据特征和存取方式不同，进行了一系列数据布局优化方法，包括针对 PC 和手机场景中大量生命周期短、可靠性要求不高的数据的高效数据统一管理方法，结合存储的制成差异和数据访问热度的地址分配方法（ICCD, DAC）

作为负责人主持一项重庆市研究生科研创新项目：

- 基于闪存错误校验的系统读写性能优化技术研究，项目起止时间：2016 年 4 月–2017 年 3 月。

作为主要参研人参与了多项科研项目：

- 国家自然科学基金一青年基金资助，重庆大学，基于错误感知的闪存存储系统性能和寿命优化技术研究，项目起止时间：2015 年 1 月—2017 年 12 月。
- 重庆大学中央高校基金资助，重庆大学，基于错误感知的闪存存储系统的可信存储服务技术研究，项目起止时间：2014 年 5 月—2017 年 5 月。
- Hong Kong, Research Grant Council, General Research Fund, GRF 9042821 (HK CityU 11219319), “How to Utilize a Huge Number of Flash Chips to Meet the Performance and Reliability Requirements via Self-Healing and Partitioning”, HKD \$602,349, Jul 2020 – Jun 2023.
- Hong Kong, Research Grant Council, General Research Fund, GRF 9042821 (HK CityU 11219319), “Multi-layer Compression for Lean Flash Storage”, HKD \$518,999, Jul 2019 – Jun 2022.
- Hong Kong, Research Grant Council, General Research Fund, GRF 9042638 (HK CityU 11204718), “Towards Reliability-guided Robust 3D NAND Flash Memories”, HKD \$693,000, Jul 2018 – Jun 2021.
- Huawei research grant, CityU 9231168, “Reliability and Performance Optimization for eMMC/NAND Flash”, HKD \$1,118,000, Nov 2014 – Oct 2015.
- NSFC, 61572411, “Cross Layer Optimization for Embedded NAND Flash Memory Systems”, RMB \$660,000, Jan 1, 2016 - Dec 31, 2018.

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## 发表论文

### 会议论文

1. **Qiao Li**, Min Ye, Tei-Wei Kuo, Chun Jason Xue. How the common retention acceleration method of 3D NAND flash memory goes wrong? 13th USENIX Workshop on Hot Topics in Storage and File Systems (HotStorage 2021). (**Best Paper Award**)
2. **Qiao Li**, Min Ye, Yufei Cui, Liang Shi, Xiaoqiang Li, Tei-Wei Kuo, Chun Jason Xue. Shaving Retries with Sentinels for Fast Read over High-Density 3D Flash. 53rd Annual IEEE/ACM International Symposium on Microarchitecture (MICRO 2020). (**CCF-A, AR: 66/422=15.6%**)
3. **Qiao Li**, Liang Shi, Jun Yang, Youtao Zhang, Chun Jason Xue: Leveraging Approximate Data for Robust Flash Storage. 56th ACM/IEEE Design Automation Conference (DAC 2019). (**CCF-A, AR: 18.9%**)
4. **Qiao Li**, Min Ye, Yufei Cui, Liang Shi, Xiaoqiang Li, Chun Jason Xue: Sentinel Cells Enabled Fast Read for NAND Flash. 11th USENIX Workshop on Hot Topics in Storage and File Systems (HotStorage 2019).
5. **Qiao Li**, Liang Shi, Riwei Pan, Cheng Ji, Xiaoqiang Li, Chun Jason Xue: Selective Compression Scheme for Read Performance Improvement on Flash Devices. IEEE International Conference on Computer Design (ICCD 2018). (**CCF-B, AR: 66/228=28.9%**)
6. **Qiao Li**, Liang Shi, Chun Jason Xue, Qingfeng Zhuge, Edwin Hsing-Mean Sha: Improving LDPC performance via asymmetric sensing level placement on flash memory. 22nd Asia and South Pacific Design Automation Conference (ASP-DAC 2017). (**CCF-C, Best Paper Nominee**)
7. **Qiao Li**, Liang Shi, Yejia Di, Yajuan Du, Kaijie Wu, Chun Jason Xue, Qingfeng Zhuge, Edwin Hsing-Mean Sha: A PV aware data placement scheme for read performance improvement on LDPC based flash memory: work-in-progress. International Conference on Hardware/Software Codesign and System Synthesis (CODES+ ISSS 2017). (**CCF-B**)
8. **Qiao Li**, Liang Shi, Yejia Di, Yajuan Du, Chun Jason Xue, Edwin Hsing-Mean Sha: Exploiting Process Variation for Read Performance Improvement on LDPC Based Flash Memory Storage Systems. IEEE International Conference on Computer Design (ICCD 2017). (**CCF-B**)
9. **Qiao Li**, Liang Shi, Yejia Di, Yajuan Du, Chun Jason Xue, Chengmo Yang, Qingfeng Zhuge, Edwin Hsing-Mean Sha: Improving read performance via selective Vpass reduction on high density 3D NAND flash memory. IEEE 6th Non-Volatile Memory Systems and Applications Symposium (NVMSA 2017).
10. **Qiao Li**, Liang Shi, Chun Jason Xue, Kaijie Wu, Cheng Ji, Qingfeng Zhuge, Edwin Hsing-Mean Sha: Access Characteristic Guided Read and Write Cost Regulation for Performance Improvement on Flash Memory. 14th USENIX Conference on File and Storage Technologies (FAST 2016). (**CCF-A**)
11. **Qiao Li**, Liang Shi, Congming Gao, Kaijie Wu, Chun Jason Xue, Qingfeng Zhuge, Edwin Hsing-Mean Sha: Maximizing IO performance via conflict reduction for flash memory storage systems. Design, Automation & Test in Europe Conference & Exhibition (DATE 2015). (**CCF-B**)
12. Hongchao Du, **Qiao Li**, Riwei Pan, Tei-Wei Kuo, Chun Jason Xue: Multi-Granularity Shadow Paging with NVM Write Optimization for Crash-Consistent Memory-Mapped I/O.

- IEEE International Symposium on High-Performance Computer Architecture (HPCA 2023). (CCF-A)
13. Yina Lv, Liang Shi, **Qiao Li**, Congming Gao, Yunpeng Song, Longfei Luo, Youtao Zhang: MGC: Multiple-Gray-Code for 3D NAND Flash based High-Density SSDs. IEEE International Symposium on High-Performance Computer Architecture (HPCA 2023). (CCF-A)
  14. Xuan Sun, Hu Wan, **Qiao Li**, Chia-Lin Yang, Tei-Wei Kuo, Chun Jason Xue: Rm-ssd: In-storage computing for large-scale recommendation inference. IEEE International Symposium on High-Performance Computer Architecture (HPCA 2022). (CCF-A)
  15. Yajuan Du, Yuan Gao, **Qiao Li**: Work-in-Progress: Prediction-based Fine-Grained LDPC Reading to Enhance High-Density Flash Read Performance. ACM International Conference on Compilers, Architecture, and Synthesis for Embedded Systems (CASES 2022). (CCF-C)
  16. Yunpeng Song, **Qiao Li**, Yina Lv, Changlong Li, Liang Shi: DWR: differential wearing for read performance optimization on high-density NAND flash memory. Design, Automation & Test in Europe Conference & Exhibition (DATE 2022). (CCF-B)
  17. Yufei Cui, Ziquan Liu, **Qiao Li**, Antoni B Chan, Chun Jason Xue. Bayesian Nested Neural Networks for Uncertainty Calibration and Adaptive Compression. IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR 2021). (CCF-A)
  18. Yina Lv, Liang Shi, **Qiao Li**, Chun Jason Xue, Edwin H-M Sha. Access characteristic guided partition for read performance improvement on solid state drives. 57th ACM/IEEE Design Automation Conference (DAC 2020). (CCF-A, AR: 228/984=23.17%)
  19. Min Ye, **Qiao Li**, Jianqiang Nie, Tei-Wei Kuo, Chun Jason Xue. Valid window: a new metric to measure the reliability of NAND flash memory. Design, Automation & Test in Europe Conference & Exhibition (DATE 2020). (CCF-B)
  20. Yufei Cui, Ziquan Liu, Wuguannan Yao, **Qiao Li**, Antoni B Chan, Tei-wei Kuo, Chun Jason Xue. Fully Nested Neural Network for Adaptive Compression and Quantization. 28th International Joint Conference on Artificial Intelligence (IJCAI 2019). (CCF-A)
  21. Yufei Cui, **Qiao Li**, Sarana Nutanong, Chun Jason Xue: Online Rare Category Detection for Edge Computing. Design, Automation & Test in Europe Conference & Exhibition (DATE 2019). (CCF-B)
  22. Yu Liang, **Qiao Li**, Chun Jason Xue: Mismatched Memory Management of Android Smartphones. 11th USENIX Workshop on Hot Topics in Storage and File Systems (HotStorage 2019).
  23. Congming Gao, Min Ye, **Qiao Li**, Chun Jason Xue, Youtao Zhang, Liang Shi, Jun Yang: Constructing Large, Durable and Fast SSD System via Reprogramming 3D TLC Flash Memory. 52nd Annual IEEE/ACM International Symposium on Microarchitecture (MICRO 2019). (CCF-A)
  24. Yina Lv, Liang Shi, **Qiao Li**, Congming Gao, Chun Jason Xue, Edwin Hsing-Mean Sha: Optimizing Tail Latency of LDPC based Flash Memory Storage Systems Via Smart Refresh. IEEE International Conference on Networking, Architecture and Storage (NAS 2019).
  25. Cheng Ji, Lun Wang, **Qiao Li**, Congming Gao, Liang Shi, Chia-Lin Yang, Chun Jason Xue: Fair Down to the Device: A GC-Aware Fair Scheduler for SSD. IEEE 8th Non-Volatile Memory Systems and Applications Symposium (NVMSA 2019).

26. Huizhang Luo, Liang Shi, **Qiao Li**, Chun Jason Xue, Edwin Hsing-Mean Sha: Energy, latency, and lifetime improvements in MLC NVM with enhanced WOM code. 23rd Asia and South Pacific Design Automation Conference (ASP-DAC 2018). (**CCF-C**)
27. Chao Wu, Cheng Ji, **Qiao Li**, Chenchen Fu, Chun Jason Xue: Maximizing I/O throughput and minimizing performance variation via reinforcement learning based I/O merging for SSDs: work-in-progress. International Conference on Compilers, Architecture and Synthesis for Embedded Systems (CASES 2018). (**CCF-C**)
28. Yejia Di, Liang Shi, Congming Gao, **Qiao Li**, Chun Jason Xue: Revisiting wear leveling design on compression applied 3D NAND flash memory: work-in-progress. International Conference on Hardware/Software Codesign and System Synthesis (CODES+ ISSS 2018). (**CCF-B**)
29. Yejia Di, Liang Shi, Congming Gao, **Qiao Li**, Kaijie Wu, Chun Jason Xue: Loss is Gain: Shortening Data for Lifetime Improvement on Low-Cost ECC Enabled Consumer-Level Flash Memory. ACM Great Lakes Symposium on VLSI (GLVLSI 2018). (**CCF-C**)
30. Congming Gao, Liang Shi, Yejia Di, **Qiao Li**, Chun Jason Xue, Edwin Hsing-Mean Sha: An Efficient Cache Management Scheme for Capacitor Equipped Solid State Drives. ACM Great Lakes Symposium on VLSI (GLVLSI 2018). (**CCF-C**)
31. Yajuan Du, **Qiao Li**, Liang Shi, Deqing Zou, Hai Jin, Chun Jason Xue: Reducing LDPC Soft Sensing Latency by Lightweight Data Refresh for Flash Read Performance Improvement. 54th ACM/EDAC/IEEE Design Automation Conference (DAC 2017). (**CCF-A**)
32. Yajuan Du, Deqing Zou, **Qiao Li**, Liang Shi, Hai Jin, Chun Jason Xue: Laldpc: Latency-aware LDPC for Read Performance Improvement of Solid State Drives. IEEE Conference on Mass Storage Systems and Technologies (MSST 2017). (**CCF-B**)
33. Cheng Ji, Li-Pin Chang, Liang Shi, Chao Wu, **Qiao Li**, Chun Jason Xue: An Empirical Study of File-System Fragmentation in Mobile Storage Systems. 8th USENIX Workshop on Hot Topics in Storage and File Systems (HotStorage 2016).

## 期刊论文

1. **Qiao Li**, Min Ye, Yufei Cui, Tianyu Ren, Tei-Wei Kuo, Chun Jason Xue: Resolving the Reliability Issues of Open Blocks for 3-D NAND Flash: Observations and Strategies. IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, 2022. (**CCF-A**)
2. **Qiao Li**, Liang Shi, Yufei Cui, Chun Jason Xue: Exploiting Asymmetric Errors for LDPC Decoding Optimization on 3D NAND Flash Memory. IEEE Transactions on Computers (TC), 2020. (**CCF-A**)
3. **Qiao Li**, Liang Shi, Yejia Di, Congming Gao, Cheng Ji, Yu Liang, Chun Jason Xue: Process Variation Aware Read Performance Improvement for LDPC-Based nand Flash Memory. IEEE Transactions on Reliability (TR), 2020.
4. **Qiao Li**, Liang Shi, Congming Gao, Yejia Di, Chun Jason Xue: Access Characteristic Guided Read and Write Regulation on Flash Based Storage Systems. IEEE Transactions on Computers (TC), 2018. (**CCF-A**)
5. Yufei Cui, Yu Mao, Ziquan Liu, **Qiao Li**, Antoni B Chan, Xue Liu, Tei-Wei Kuo, Chun Jason Xue: Variational Nested Dropout. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2023. (**CCF-A**)

6. Yajuan Du, Yuan Gao, Siyi Huang, **Qiao Li**: LDPC Level Prediction Towards Read Performance of High-Density Flash Memories. IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, 2023. **(CCF-A)**
7. Yufei Cui, Shangyu Wu, **Qiao Li**, Antoni B Chan, Tei-Wei Kuo, Chun Jason Xue: Bits-Ensemble: Toward Light-Weight Robust Deep Ensemble by Bits-Sharing. IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, 2022. **(CCF-A)**
8. Min Ye, **Qiao Li**, Congming Gao, Shun Deng, Tei-Wei Kuo, Chun Jason Xue: Stop unnecessary refreshing: extending 3D NAND flash lifetime with ORBER. CCF Transactions on High Performance Computing, 2022.
9. Yufei Cui, **Qiao Li**, Tei-Wei Kuo, Chun Jason Xue. Online Rare Category Identification and Data Diversification for Edge Computing. IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (TCAD), 2021. **(CCF-A)**
10. Yufei Cui, Wuguannan Yao, **Qiao Li**, Antoni B Chan, Chun Jason Xue. Accelerating Monte Carlo Bayesian Prediction via Approximating Predictive Uncertainty Over the Simplex. IEEE Transactions on Neural Networks and Learning Systems (TNNLS), 2020. **(CCF-B)**
11. Chao Wu, **Qiao Li**, Cheng Ji, Tei-Wei Kuo, Chun Jason Xue. Boosting User Experience via Foreground-Aware Cache Management in UFS Mobile Devices. IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (TCAD), 2020. **(CCF-A)**
12. Yu Liang, Cheng Ji, Chenchen Fu, Rachata Ausavarungrun, **Qiao Li**, Riwei Pan, Siyu Chen, Liang Shi, Tei-Wei Kuo, Chun Jason Xue. iTRIM: I/O-Aware TRIM for Improving User Experience on Mobile Devices. IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (TCAD), 2020. **(CCF-A)**
13. Congming Gao, Liang Shi, **Qiao Li**, Kai Liu, Chun Jason Xue, Jun Yang, Youtao Zhang: Aging Capacitor Supported Cache Management Scheme for Solid-State Drives. IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (TCAD), 2020. **(CCF-A)**
14. Chao Wu, Cheng Ji, **Qiao Li**, Congming Gao, Riwei Pan, Chenchen Fu, Liang Shi, Chun Jason Xue: Maximizing I/O Throughput and Minimizing Performance Variation via Reinforcement Learning Based I/O Merging for SSDs. IEEE Transactions on Computers (TC), 2020. **(CCF-A)**
15. Yejia Di, Liang Shi, Congming Gao, **Qiao Li**, Chun Jason Xue, Kaijie Wu: Minimizing Retention Induced Refresh Through Exploiting Process Variation of Flash Memory. IEEE Transactions on Computers (TC), 2019. **(CCF-A)**
16. Huizhang Luo, Qing Liu, Jingtong Hu, **Qiao Li**, Liang Shi, Qingfeng Zhuge, Edwin H-M Sha: Write Energy Reduction for PCM via Pumping Efficiency Improvement. ACM Transactions on Storage (TOS), 2018. **(CCF-A)**
17. Congming Gao, Liang Shi, Yejia Di, **Qiao Li**, Chun Jason Xue, Kaijie Wu, Edwin Hsing-Mean Sha: Exploiting Chip Idleness for Minimizing Garbage Collection - Induced Chip Access Conflict on SSDs. ACM Transactions on Design Automation of Electronic Systems (TODAES), 2018. **(CCF-B)**

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## 专利

1. 一种基于闪存错误校验的读写调制方法，申请号：CN201510014945.3，授权公告号：CN104575618B，发明人：石亮，**李乔**，高聪明，吴凯劼，诸葛晴凤，沙行勉（授权）
2. 一种闪存设备的访问方法和装置，申请号：CN201680000818.0，发明人：石亮，薛春，**李乔**，单东方，徐君，王元钢
3. 一种数据读取方法及装置，申请号：CN201611239752.9，发明人：石亮，**李乔**，王元钢（授权）
4. METHOD AND APPARATUS FOR ACCESSING FLASH MEMORY DEVICE，申请号：PCT/CN2016/074140，发明人：石亮，薛春，**李乔**，单东方，徐君，王元钢（授权）
5. METHOD FOR READING DATA, AND FLASH MEMORY DEVICE，申请号：PCT/CN2016/113085，发明人：常乐，石亮，**李乔**，王元钢（授权）
6. 一种闪存制程差异的检测方法，申请号：CN201710600498.9，发明人：石亮，**李乔**，薛春
7. 一种基于闪存制程差异的数据布局方法，申请号：CN201710601039.2，发明人：石亮，**李乔**，薛春
8. 一种在线挖掘闪存制程差异现象优化刷新的方法，申请号：CN201711068052.2，发明人：石亮，底晔佳，高聪明，**李乔**，吴凯劼，沙行勉
9. 一种数据读取的方法及闪存控制器，申请号：CN201710698122.6，发明人：石亮，**李乔**，底晔佳，戴芬，王元钢（授权）
10. 一种闪存中近似数据存储方法，申请号：CN201910164738.4，发明人：**李乔**，石亮，薛春
11. 3d 闪存中阈值电压的调整方法、系统以及 3d 闪存，中国专利申请号：CN110322907A, 发明人：薛春，**李乔**，石亮，李晓明，吴大畏（授权）