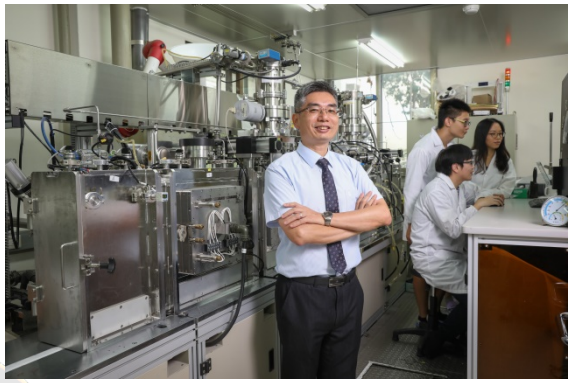
化工/材料/科技：



賴志煌 先生

Chih-Huang Lai

座右銘

凡走過必留下痕跡。

Where you walk, you will leave traces.

年齡: 54 歲（1966 年 12 月）

學歷

美國史丹佛大學 材料科學與工程研究所 博士
國立清華大學 材料科學與工程研究所 碩士
國立清華大學 材料科學與工程系 學士

曾任

國立清華大學工學院 副院長兼學士班主任
國立清華大學 材料科學與工程學系 教授兼主任
台灣磁性技術協會 理事長
國際電機電子工程師學會(IEEE)磁性學會 會員委員會主席
教育委員會主席

現任

國立清華大學工學院 院長
國立清華大學 材料科學與工程學系 講座教授

評審評語

長期投入薄膜材料研究，融合材料與製程之研發，在高密度磁性記憶體、磁感測器及薄膜太陽電池的論文與專利皆領先國際，成果技轉國內外領導廠商，績效卓著。

Renowned for the thin-film technology development with innovation of materials and processes, especially for the applications of high-density magnetic memory, sensors and solar cells. Accomplished important technology transfers to leading companies with outstanding performance.

得獎感言

首先謝謝東元科技文教基金會及審查委員對我個人及研究團隊的肯定。對從事材料研究的學者，「東元獎」不僅代表在學術上的創新，更重要的是於產業應用的突破。感謝多位材料界先進之提攜，我幸運地能在磁性與太陽能領域開花結果。科技部與清華大學的經費支持，我才得以建立完整的薄膜製程與量測實驗室。很多長期合作的業界夥伴，不僅在經費上給予資助，更在研究方向上多所指導。我也要誠摯地謝謝所有曾經在「尖端儲存與能源實驗室」努力過的人，沒有他們的熱情與衝勁，很多的創意皆無法真正被實現。對於我摯愛的家人，你們的支持與傾聽永遠是我勇往直前的最大動力。研究對我而言，是個享受探索新知的過程。東元獎的榮譽，更添加了在此過程中，往前邁進的能量，期盼能對社會與產業有更多的貢獻。

《熱情與堅持，追根究柢—夢幻記憶體領航者》

看到清華大學工學院院長賴志煌的學經歷，每個人都覺得他人生一路順暢。但實際上，他第一次的升等就因為名額的限制，未能順利成功。一切按計畫進行不喜歡「驚喜」的他，卻總能加倍的努力，創造出他人眼中的傳奇。從小深受父親嚴以律己、追求完美的影響，從求學到研究教學，始終以「設立目標，努力達成」面對任何挑戰。當他埋首 20 年持續研發的磁性記憶體（MRAM），預定從今年開始量產的同時，他又設定目標帶領研究團隊利用全球首創的電子自旋流投入下世代 MRAM 研發，計畫在 4 年後做出讀寫速度更快、更省電、斷電時資訊也不會流失的「不失憶記憶體」，不斷自我挑戰。

對「東元獎」的期望

「東元獎」創設至今已超過 20 餘年，秉持「科文共裕」的設獎精神，獎勵科技領域與人文藝術，是台灣廣受肯定的重要榮譽獎項。對長年埋首於科技研究的學者而言，獲得「東元獎」，不僅彰顯他們的創新研究成果，更肯定他們對於國家產業發展的貢獻。尤其對於願意長期耕耘特定領域，不追逐熱門課題，但能建立扎實技術的研究學者，有正面鼓舞的作用。而對年輕研究人員與學子而言，獲獎者的努力歷程，更提供一個學習的典範，並導引他們的研究態度。由於歷屆得獎者皆是各領域傑出人士與社會標竿，建議透過「東元獎聯誼會」針對趨勢性的議題辦理研討會，除了讓獲獎者可以持續在跨界的平台上交流，並可為產業與政府政策提出建言，進一步發揮「東元獎」對社會的影響力。

成就歷程

賴志煌教授自 1997 年於美國史丹佛大學獲得材料工程博士後，先至矽谷的磁碟公司服務，於 1998 年回國至清華大學材料系，擔任系裡第一位助理教授，從事磁性薄膜應用於記憶體與磁紀錄相關的研究。回國 10 年後，

2008 年開始跨足 CIGS(銅銦鎵硒)薄膜太陽能電池的研究。這兩個看似相關度不高的領域，由於他的核心技術—「薄膜濺鍍技術」而得以串連在一起。賴教授不僅擅長於濺鍍製程的開發與元件製作，更有設計濺鍍機台、開發新的靶材材料、與元件檢測技術的能力，因此得以整合於磁性元件及 CIGS 太陽能電池的上(靶材、機台)中(製程)下(元件、檢測)游需求，建立產學平台。啟蒙於史丹佛大學的指導教授，賴教授相當重視研發成果於產業界的落實。他於磁性元件與 CIGS 太陽能電池的研發，除材料開發外，皆能做到試量產的原型產品，並能依照全球產業預估的路徑圖，來提供國內業者研發的方向。而他所累積獲證的 36 項專利及數十次的技轉，也多次協助產業界完成技術升級與創新。而在學術發表上，已有超過 200 篇 SCI 期刊論文，深入的學術基礎探討也厚植了應用於產業技術的基石。

賴教授於 2019 年針對新穎的磁性記憶體，引進突破性的反鐵磁材料，並利用自旋電子流，直間翻轉磁偶矩，使得記憶單元的熱穩定性能因反鐵磁材料而大幅提升，但又不增加寫入電流。這解決了磁性記憶體長久的挑戰，因此成果發表於 Nature Materials，寫下個人學術研究嶄新的一頁。

具體貢獻事蹟

一、學術研究:賴志煌教授的學術研究，以薄膜材料的製程與應用為主，尤其專注於磁性與太陽能薄膜元件的研發。由新穎的材料與製程切入，並搭配獨特的分析技術，得以在相關的元件上有突破性的進展，因此獲得三次科技部傑出研究獎、IEEE Fellow 與中國材料學會會士(MRS-T Fellow)的肯定。

於磁性薄膜的研究，深耕磁性記憶體(MRAM)，開發多種新穎材料結構，尤其是在利用電流寫入多層膜的磁性記憶體上，獲得十餘個專利，將 MRAM 由實驗室推向產業界，是台灣推動此項新穎記憶體的重要推手。另外對於下世代高密度磁碟片的開發，藉由創新的"類原子層濺鍍"製程，屢次突破磁碟片的紀錄密度，並成為下世代磁碟片材料 FePt 的全球領先團隊。磁性元件相關的成果發表在 Nature Materials, Advance Materials 等重要期刊。於 CIGS 薄膜太陽能電池開發上，開創以四元 CIGS 靶材濺鍍的新穎製程，在無後硒化的情況下，元件的轉換效率於可撓基板上，已成功地超過 15%，是此新穎製程的世界最高效率。因此成果得以發表於太陽能領域頂尖的期刊，包含 Advanced Energy Materials, Nano Energy 等。

二、產業連結:賴教授與產業界有相當密切的合作，除了多項的產學合作計畫外，也多次技轉關鍵技術予廠商，提升產業技術。賴教授並促成中鋼與清華成立「先進特殊合金中心」，協助中鋼公司於濺鍍靶材與特殊合金領域的擴展。此外，也與上銀光電於清華成立 CIGS 研發中心，積極發展薄膜太陽能電池於建築上的應用。由於在產學與技轉的傑出表現，賴教授也獲得**科技部傑出技術移轉貢獻獎與清華大學的傑出產學合作獎**。

研究展望

賴志煌教授過去多年以薄膜技術的核心能力，致力發展於磁性記憶體、感測器與

太陽能電池的應用。由於磁性記憶體的發展，將對半導體的後摩爾世代產生重要的影響，未來團隊將更緊密的與產業界結合，導入磁性關鍵技術，持續維持台灣於半導體的技術優勢。而在薄膜太陽能電池上，戮力於與建築結合，期許於再生能源上，提供實質的解決方案。

Prospective of "TECO Award"

TECO award has been established for more than 20 years. With its spirit for promoting progress on both technology and culture, TECO award has become the most prestigious award in Taiwan. For scholars devoting on technology development, getting the TECO award does not only reveal their novelty of research but confirm their significant contributions to industry. Especially, TECO award inspires those who have been devoted themselves on a specific topic for long time to build a solid technology. To further increase the impacts of TECO award, the foundation can invite awardees to provide their opinions on social or technological topics through workshops, which can promptly give advices to government and industry.

History of Achievements

Prof. Chih-Huang Lai received his PhD. from Stanford University in 1997 and then joined a magnetic head company in Silicon Valley. He joined Department of Materials Science and Engineering, National Tsing Hua University in 1998 and became the first Assistant Professor in the department. He worked on the magnetic memory (MRAM) and storage for the first 10 years and started to work on CIGS thin film solar cells since 2008. Although these two fields seem not to be correlated, he applied his core capability-thin film sputtering technology to link both topics and achieved outstanding outcomes. Prof. Lai is not only good at sputtering process and device fabrication, his group owns the varieties of technology on design of sputtering tools and development of target materials. Therefore, he can build a platform to bridge the academic research with industrial applications. To be enlightened by his advisor at Stanford, Prof. Robert White, Prof. Lai emphasizes the realization of his research into real applications. His researches on magnetic and solar devices can both reach prototype products so that he can provide guidelines for industry on the future development. He has awarded 36 patents and more than 200 SCI papers. He also has several technology transfers to industry to strengthen its technical level.

Prof. Lai introduced an antiferromagnetic layer into novel magnetic memory devices in 2019, which significantly enhances the thermal stability of memory cells without increasing the writing current. This demonstration solves a long standing problem for MRAM so the results are published in Nature Materials, a breakthrough for his

research career.

Technical Contributions

1. Academic Contribution:

The focus of Prof. Lai's research is on the applications of thin films, especially on the magnetic devices and solar cells. For magnetic thin films, he worked on magnetic memory (MRAM) and obtained more than 10 patents. He is the key person to drive the MRAM technology in Taiwan from academy to industry. He also worked on high-density magnetic recording media. Through his novel "atomic scale sputtering" process, he reached a record high density of FePt-based magnetic media. The related results have been published on Nature Materials and Advanced Materials. Regarding CIGS thin film solar cells, he invented a direct sputtering process from a quaternary CIGS target, by which a high conversion efficiency over 15% can be achieved without any post-selenization. The results have been published on Advanced Energy Materials and Nano Energy. Because of his excellent performance on these fields, he was awarded the outstanding research award three times from Ministry of Science and Technology and recognized as an IEEE fellow and an MRS-T fellow.

2. Industry contribution

Prof. Lai has been closely collaborating with industry. In addition to industrial research projects, he also has several important technology transfers to companies. Prof. Lai established Tsing Hau-China Steel Engineering Research Center (ERC) for advanced alloys, which supports the development of sputtering targets and special alloys for China Steel Co. He also collaborates with the Hiwin group on CIGS solar cells and promotes the integration of solar cells with buildings. Due to his exceptional performance on the industrial contributions, he obtained the outstanding technology transfer award from Ministry of Science and Technology and the outstanding industry-university cooperation award from Tsing Hua University.

Future Prospects in Research

Prof. Lai has been working on thin film-based magnetic memory, sensors and solar cells for decades. Because the advancement of MRAM will bring essential impacts for semiconductor industry beyond Moore's law, Prof. Lai will support our industry to implement the key technology developed in the lab and to maintain Taiwan's technological advantages in semiconductors. For the development of thin film solar cells, he will strive to integrate solar cells with buildings and to contribute to renewable energy.