

繼上次獲獎2019年已過了7年，這些年清華整體產學研究蓬勃發展，不僅是總經費上有大幅提升，對產業影響範圍更大。這次能脫穎而出，應該與微波/電漿的產學研究，普遍具有環保、節能、永續特性相關。

微波會影響電漿，電漿也可產生微波。彼此交互作用複雜、多變。我們將分為三個主要領域：1. 微波電漿；2. 微波與傳統材料熱處理；3. 微波與先進材料熱處理。

1. 微波電漿：半導體電漿機台與台灣最強的半導體產業發展有關，重要性不言而喻；磁約束高溫電漿(核融合發電)更與國家幾乎所有產業息息相關，是解決能源挑戰的關鍵。
2. 微波與傳統材料熱處理：微波磁性材料在通訊與國防科技發展密切相關。我們可以操控磁性材料的微波響應特性；此外，微波可促進生質柴油反應，結合催化劑，用於生質柴油生產，其速度比傳統方法快14倍。該方法具有極高的能源效率，並顯著降低了碳排放。
3. 微波與先進材料熱處理：可分成兩大部分微波碳纖維與微波半導體。我們開發了一種微波碳纖維處理器，將最耗能的氧化過程，縮短反應時間8-9倍；在微波對半導體材料的熱處理上，我們提出了一種創新的微波高溫熱處理系統，實現均勻的微波加熱。微波能量可以選擇性地高效加熱樣品，同時保持腔體溫度接近室溫，從而在能源效率、碳減排和環境、社會和治理(ESG)方面帶來顯著優勢。

此次獲獎，我也希望特別感謝趙賢文博士後研究員與柯雅婷小姐。前者把技術落實，研發各種微波反應腔；後者協助處理繁瑣的計畫行政事務。另外我也要感謝實驗室所有成員與給我們機會的諸多合作廠商。謝謝大家。

It has been seven years since I last received this award in 2019. Over these years, industry–academia collaboration and research at National Tsing Hua University have flourished. Not only has the overall research funding increased substantially, but the scope and impact of our research on industry have also expanded significantly. I believe that our recognition this time is closely related to the fact that our industry–academia research on microwaves and plasmas generally emphasizes environmental sustainability, energy efficiency, and carbon reduction.

Microwaves can influence plasmas, while plasmas can also generate microwaves. The interactions between them are complex, dynamic, and highly diverse. Our research can be broadly divided into three major areas: (1) microwave plasma, (2) microwave processing of conventional materials, and (3) microwave processing of advanced materials.

1. Microwave Plasma

Semiconductor plasma processing equipment is closely connected to Taiwan's world-leading semiconductor industry, and its importance cannot be overstated. At the other end of the spectrum, magnetically confined high-temperature plasmas for nuclear fusion energy are relevant to virtually every sector of the national economy and represent one of the key technologies for addressing future energy challenges.

2. Microwave Processing of Conventional Materials

Our research on microwave magnetic materials is closely related to advances in communications and defense technologies. We have developed approaches to manipulate and control the microwave response of magnetic materials for various applications. In addition, microwaves can significantly enhance the reactions involved in biodiesel production. By combining microwave heating with catalysts, we have demonstrated a biodiesel production process that is approximately 14 times faster than conventional methods. This approach offers exceptionally high energy efficiency while substantially reducing carbon emissions.

3. Microwave Processing of Advanced Materials

This area consists of two major research directions: microwave processing of carbon fibers and microwave thermal processing of semiconductor materials. For carbon fibers, we have developed a microwave carbon-fiber processor that reduces the processing time of the highly energy-intensive oxidation stage by a factor of approximately eight to nine. For semiconductor materials, we have proposed an innovative high-temperature microwave thermal-processing system capable of achieving highly uniform microwave heating. Microwave energy can selectively and efficiently heat the sample while maintaining the surrounding chamber at nearly room

temperature. This approach therefore provides significant advantages in energy efficiency, carbon reduction, and environmental, social, and governance (ESG) performance.

Finally, on receiving this award, I would like to express my special appreciation to Dr. Hsien-Wen Chao, our postdoctoral researcher, and Ms. Ya-Ting Ko. Dr. Chao has played a key role in turning our concepts into practical technologies by developing a variety of microwave reaction chambers and systems. Ms. Ko has provided invaluable assistance in handling the extensive administrative work associated with our research projects. I would also like to thank all the members of our laboratory, as well as our many industrial collaborators who have given us opportunities to transform our research into practical applications. Thank you all very much.