Autonomous Materials Research utilizing Robots and AI

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Recent advancements in robotics and artificial intelligence (AI) have revolutionized the field of materials research, offering unprecedented levels of automation and precision. Our latest research focused on two pioneering autonomous materials research systems: a force-controlled robotic mechanochemical synthesis system and an autonomous robotic experimentation system for powder X-ray diffraction.

The force-controlled robotic mechanochemical synthesis system utilizes a robotic powder grinding mechanism that applies a precisely controlled and constant mechanical force. This approach enhances reproducibility and allows for detailed analysis of reaction pathways. Our experiments with perovskite materials have demonstrated that this robotic method provides significantly higher reproducibility than traditional manual grinding and ball milling. We could dynamically control the reaction pathways by varying the grinding forces and speeds, leading to new insights and discoveries in chemical reaction mechanisms.

In parallel, our development of the autonomous robotic experimentation system for powder X-ray diffraction (ARE-XRD) has enabled real-time, in-situ monitoring of chemical reactions. This system automates the entire experimental process, from sample preparation to data analysis, allowing continuous, unattended operation. Integrating ARE-XRD with our robotic mechanochemical synthesis system has proven particularly powerful, providing real-time feedback and enabling precise control over experimental conditions.

These combined advancements highlight the potential of robotics and AI to revolutionize materials research. The ability to automate and precisely control experimental processes opens new avenues for discovering and understanding complex chemical reactions. In this talk, I will present the design, construction, and experimental results of our robotic mechanochemical synthesis system and the ARE-XRD system. We will discuss the broader implications of these technologies for materials science and outline future directions for integrating robotics and AI in scientific research.