Polycrystalline materials are ubiquitous in all engineering structures and devices. Any two misaligned grains in these materials form a planar defect called a grain boundary. Boundaries can trap electrons in certain devices and can also demonstrate novel properties depending on the particular geometric misalignment, such as in superconducting oxides in regard to electrical transport. But that geometric misalignment is not the same between any two grains, even of the same material, making grain boundaries and interfaces among the least understood in materials science.

Identifying boundary types that have similar electrical responses has important relevance for next-generation technology like high temperature superconducting quantum interference devices (squids) for magnetic cardiograms and rare mineral explorations. Also, identifying chemical additions that can improve certain properties at boundaries has important implications; consider how adding manganese to steel in order to abate its brittleness could have changed the story of the Titanic. Already special boundary engineering has enabled zinc oxide varistors as surge protectors; positive temperature coefficient materials for temperature-activated switches; and new thin film transistors.

Siu-Wai Chan has focused on a systematic study of grain boundaries and interfaces relating their geometric structure, chemistry, and energetics with their electrical properties. Her research activities include the study of grain boundaries and interfaces in metals and oxides, particularly the fast ionic conductors and YBCO, a high-temperature oxide superconductor. She has placed emphasis on isolating and examining particular boundaries and their structures via high-resolution transmission electron microscopy (TEM) and measuring electrical properties via scanning squid microscopy. She has also developed methods to increase twin boundary density in superconducting oxide wires pinning magnetic flux lines and increase their super-current capacity.

Current research involves oxide crystallites with special metal additions as catalysts. Many researchers propose that the boundaries and interfaces exist in these catalysts play special roles in stabilizing the nanostructure and promoting reactions. Her early work on grain rotations explains accelerated grain growth in nanoparticles and thus reduced effectiveness as catalysts. These nanocrystals prepared in a single size and shape will be used to investigate optimization of catalytic reactions with crystallites of special shape and size. She investigates certain surfaces as active catalysts using scanning tunneling microscopy and spectroscopy and is exploring new techniques such as in-situ TEM applied to crystallites to look at their reduction and oxidation as they occur to lend insight into catalysis mechanism. She has five U.S. patents.

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