Quantum Materials and Thermoplasmonics: Revolutionizing Solar Desalination, Mineral Extraction, and Blue Energy Harvesting

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The thrilling intersection of solid-state physics and environmental technology is about to unfold a new era for sustainable solutions. This talk pivots around the innovative capabilities of quantum materials - specifically, nickel selenide (NiSe) and cobalt selenide (CoSe). As topological nodal-line semimetals, these quantum materials are pushing the boundaries of environmental challenges, offering promising opportunities from solar desalination to mineral recovery and blue energy generation.Notably, NiSe and CoSe, with their unique anisotropic dielectric properties, stimulate additional plasmonic resonances, creating a broadband matching with sunlight radiation spectrum - a remarkable feature for efficient energy conversion in thermoplasmonics.

Traditionally, thermoplasmonics employed gold and silver nanoparticles, but the associated high costs restrict their scalability. In contrast, NiSe and CoSe offer compelling advantages, enabling a 330% and 690% increase in transmembrane flux for desalination, respectively, and significantly reducing raw material costs by 24 and 11 times, demonstrating an impressive potential for sustainability.

These innovative materials further unlock new possibilities for mineral recovery from the sea. Based on the thermoplasmonic effects in NiSe and CoSe nanofillers, solar-powered photothermal membrane crystallization facilitates the rapid vaporization and subsequent nucleation and crystallization of high-quality salt crystals, furthering the potential of sustainable mineral extraction. Definitely, solar-powered photothermal membrane crystallization intensifies the selective crystallization of solutes from brine, paving the way for the sea to serve as a renewable mine.

Beyond merely addressing water scarcity, this novel approach transforms the desalination process into an energy-generating mechanism. The hypersaline brine generated can fuel a reverse electrodialysis unit, transforming the salinity gradient into electrochemical energy and thereby pioneering 'blue energy' generation.

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