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Quantum Materials for Next-Generation Technologies: Challenges and Future Directions in Energy Devices and Quantum Computing

Quantum materials, characterized by the emergence of quantum mechanical effects at macroscopic scales, have garnered significant interest due to their potential to revolutionize various technological domains. This class of materials, including graphene, topological insulators like Bismuth Selenide (Bi_2Se_3), and high-temperature superconductors such as Yttrium Barium Copper Oxide (YBCO), exhibits unique properties like zero electrical resistance and topologically protected states. Studying quantum materials is imperative to advance our understanding of complex electron, spin, and lattice interactions. Given the limitations of current technologies, there is an urgent need to explore these materials to develop next-generation quantum computing, energy storage solutions, and sensing devices. This paper addresses the critical need for continued research in quantum materials, bridging fundamental physics with transformative applications.

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