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System-Level Applications of Two-Dimensional Materials: Challenges and Opportunities

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Two-dimensional materials represent the next frontier in advanced materials for electronic applications. Their extreme thinness (3 or less atoms thick) give them great flexibility, optical transparency and an unsurpassed surface-to-volume ratio. At the same time, this family of materials has tremendously diverse and unique properties. For example, graphene is a semimetal with extremely high electron and hole mobilities, hexagonal boron nitride forms an almost ideal insulator, while MoS2 and other dichalcogenides push the limits on large area semiconductors. The growth of these materials over large areas has allows their use in numerous system-level demonstrators. For example, the zero bandgap of graphene and its ambipolar has been used in a wide variety of rf and mixed applications, including frequency multipliers, mixers, oscillators and digital modulators. At the same time, the wide bandgap of MoS2 in combination with advanced fabrication technology has enabled its use in memory cells, analog to digital converters and ring oscillators with orders of magnitude better performance than other materials for large area applications. These and other examples will be discussed to highlight the numerous new opportunities of 2D materials.