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Interface-Engineered van der Waals Heterostructures for Next-Generation Microelectronic Contacts

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The continued scaling of microelectronic devices is fundamentally constrained by non-ideal metal–semiconductor interfaces, where Fermi-level pinning and metal-induced gap states limit Schottky barrier tunability and increase contact resistance. This work proposes an integrated research and workforce framework to advance next-generation contact engineering through atomically controlled van der Waals heterostructures and critical materials innovation. Central to this effort is the development of tunable interfaces that restore near-ideal transport behavior by suppressing interfacial disorder and enabling predictable band alignment.

Leveraging expertise in carbon-based semiconducting materials, nanoscale spectroscopy, and multifunctional nanomaterials, the project explores molecular–2D hybrid architectures capable of improving charge injection efficiency, reducing barrier variability, and supporting thermionic-field emission mechanisms critical for high-performance nanoelectronic and optoelectronic devices. Density-functional-theory-guided design and advanced structural characterization will be used to correlate interfacial chemistry with carrier transport, providing pathways toward low-resistance, thermally stable contacts compatible with future microelectronic manufacturing.

Beyond device innovation, this initiative integrates workforce development to prepare a technically skilled pipeline aligned with the growing semiconductor and microelectronics sectors. By combining interface engineering, predictive materials design, and scalable training models, the program positions Hampton University as a strategic contributor to domestic microelectronics capability, supporting technological competitiveness and national supply-chain resilience.

Academic or Professional Status

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