Gaptronics: a zero-nanometer technology for photonics

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Electron tunneling, Van der Waals interaction, quantized conductance, chemical bonding and Pauli repulsion occur as two objects approach each other. The ability to control the final few nanometers of this approach curve, often with picometer precision, resulted in the development of scanning-probe microscopies and breakjunction electronics. Nevertheless, the small device footprint makes it difficult for these matured quantum technologies to be integrated into macroscopic wavelength optical applications. We address this issue by extending subatomic distance controllability to the wafer-length and wafer-scale. High aspect ratio-nanotrenches of up to 2 cm-long are fabricated on a flexible substrate. While our as-fabricated structure can be transparent to electromagnetic waves owing to the slot antenna action of the nanotrenches, inherently embedded point-contacts become activated when gentle bending closes the gap. Quantum plasmonic actions over the uniform length of nanotrenches traversing tunneling, quantized conductance and semi-classical regimes produce an extinction better than 10,000 repeatable over 10,000 times in real time that can alter resonance and symmetry as well. Our quantum line-contacts offer a versatile platform for macroscopic realization of microscopic phenomena. We also present a zero-gap technology, whereby sequential depositions with pre-patterned objectives result in tunable gaps that start from full contact-zero nanometer to hundreds of nanometers with repetitions of 100,000.