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Types of nanosensors: Capabilities and limitations

Nanosensors exhibit a high degree of functional diversity, typically classified by their transduction mechanisms such as optical, electrochemical, or piezoelectric—and target detection modalities, including chemical, biological, and environmental analytes. Their enhanced performance arises from nanoscale effects like quantum confinement and high surface-to-volume ratios, enabling highly sensitive and selective detection. Chemical nanosensors, particularly those based on carbon nanotubes and metal oxide nanoparticles, have demonstrated exceptional sensitivity to volatile organic compounds and environmental pollutants.[60] However, issues such as baseline drift, cross-sensitivity to non-target gases, and long-term stability remain unresolved.[61]

Biosensors utilizing nanostructured transducers are central to precision diagnostics. Gold nanoparticles and graphene-based platforms have enabled low detection limits and enhanced selectivity.[62] Yet, the reproducibility of such biosensors at the point-of-care scale is hampered by challenges in biointerface engineering and surface functionalization consistency.[63] Optical nanosensors provide compelling solutions for label-free and multiplexed analysis, employing phenomena such as surface plasmon resonance (SPR) and Förster resonance energy transfer (FRET).[64]

Despite their demonstrated efficacy under

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