Supplementary Information (SI) for RSC Advances.

Supplementary Materials

Multifaceted Boron Nitride Nanomaterials: A Comprehensive Review of Synthesis, Property Engineering to Multidisciplinary Applications

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Supplementary materials Table S1: History and development milestone for BN nanomaterials

Period	Milestone	Key Applications	Ref
1842	First synthesis of boron nitride (BN) from boric acid under C/N-containing conditions (W. H. Balmain)	Foundational BN chemistry and thermal stability.	1
1957	Cubic boron nitride was synthesized under high pressure (Wentorf Jr.).	Ultrahard diamond analogue used as a thermally stable abrasive	2
1960s	Pyrolytic boron nitride developed via CVD, yielding dense, high-purity BN ceramics.	BN crucibles, dielectric coatings, and reactor components with high thermal/chemical stability.	3
1980s	BN fiber coatings (BN interphase) introduced for ceramic matrix composites.	Weak BN interphase promotes damage tolerance (crack deflection)	4
1995	Boron nitride nanotubes (BNNTs) were first experimentally synthesized by arc-discharge (Chopra et al.), following theoretical prediction (1994).	Structurally analogous to carbon nanotubes. High thermal/chemical stability; reinforcement for high-temperature nanocomposites; radiation/neutron shielding.	5
2003	Continuous boron nitride fibers produced via polymer-derived precursor pyrolysis.	Lightweight reinforcement at elevated temperatures; electrically insulating yet thermally robust fibers.	6
2005	Monolayer/few-layer hexagonal BN (h-BN) (single-atom-layer BN sheet) isolated by micromechanical exfoliation.	Atomically smooth 2D dielectric; ultra-flat substrate and gate dielectric for graphene/2D electronics.	7
2013	Few-nanometer h-BN nanocoatings grown by CVD (ultrathin BN films).	Oxidation/corrosion-resistant coatings protecting metals and graphene up to high temperatures (~1100 °C).	8
2013	Macroscopic BN architectures via conformal BN coatings on conventional fibers (core-shell BN coated fibers).	Oxidation-resistant, thermally robust fiber systems for high-temperature composites/structures.	9
2013	BN quantum dots (BNQDs)	Tunable fluorescence (deep-UV to visible); bioimaging, sensing, luminescent devices.	10
2014	Large-area monolayer BN films grown by CVD.	cm-scale insulating layers for 2D electronics; oxidation-resistant coatings; improved device integration vs. powder BNNS.	11

2014	Oxygen-doped BN nanosheets by metal-free sol–gel routes	Tunable H_2 adsorption/storage via defect/heteroatom engineering; energy-storage relevance.	12
2016	h-BN shown to catalyze oxidative dehydrogenation of propane to propene.	Metal-free catalysis; BN enters heterogeneous catalysis and greener petrochemical processes.	13
2017	Super elastic 3D BNNT cellular foam/network demonstrated.	BN aerogel/foam architectures combining stability with high porosity; oil adsorption and lightweight functional materials.	14
2018	Wafer-scale single-crystal h-BN monolayers achieved via epitaxial CVD on Cu	High-quality wafer-scale 2D dielectrics; improved interfaces and reproducibility for electronics/heterostructures.	15
2019	Assembly of BN nanoribbons and nanosheets to form high-temperature-stable aerogels	Aerospace thermal protection, cryogenic insulation, extreme-environment materials (mechanically stable up to ~1400 °C).	16
2020	BNQDs adopted as co-reactants/enhancers in electrochemiluminescence (ECL) sensing platforms.	Improved signal amplification and sensitivity in biomedical and analytical diagnostics.	17
2021	Full spectrum/ multicolor emissive BN nanodots achieved via surface functionalization/defect engineering.	Full-color emitters for anti-counterfeiting inks and flexible optoelectronics.	18
2023	3D-printed BN catalytic monoliths/macroscopic BN lattices demonstrated.	Structured reactors and catalytic supports; architecture-controlled mass transfer and performance.	19
2024	Ultrahigh thermal-conductivity BN/polymer composites via BN nanosheet alignment and interface engineering (>30 W m^{-1} K^{-1}).	Thermal management materials retaining electrical insulation (electronics, batteries, power devices).	20
2025	Mature BN hybrid/core–shell fibrous composites via polymer-derived routes and CVD.	Scalable macroscopic BN architectures combining BN chemical stability with fiber mechanical strength.	21

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