Defect-Engineered TiO_2–MXene Heterostructures via Atmospheric Plasma Jet Printing: A scalable process

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We present a plasma-assisted approach for printing TiO_2–Ti_2C MXene heterostructures, targeting advanced photocatalytic applications. Using a low-powered atmospheric pressure plasma jet (APPJ), Ti_2C MXene surfaces undergo controlled in situ oxidation, enabling the formation of TiO_2 layers with tunable electronic and structural characteristics. This plasma-driven oxidation step promotes the growth of defect-rich TiO_2, enhancing light absorption and improving charge separation efficiency—features essential for high-performance photocatalysis. The generation of oxygen vacancies and mixed titanium and carbon oxidation states further broadens the absorption spectrum and increases electronic density near the Fermi level, contributing to reduced electron–hole recombination and improved catalytic activity.

Beyond oxidation, the APPJ process provides a versatile route for surface functionalisation and direct printing of MXene-based heterostructures on diverse substrates, enabling compatibility with scalable fabrication and device integration. The resulting TiO_2–Ti_2C heterostructures show strong potential as thin-film photocatalytic electrodes, relevant to environmental remediation and clean-energy applications such as wastewater treatment and hydrogen production. Their adaptability also opens opportunities in broader photocatalytic and optoelectronic technologies