Supporting Information

Carrier extraction from metallic perovskite oxide

nanoparticles

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Note 1: Sr-Deficient Sr_xNbO₃

Was selected among Sr_xNbO_3 due to its favourable photocatalytic activity, bandgap, and highest carrier mobility based on previous studies.^{1–3}

Previous work showed that Sr_xNbO_3 has cubic perovskite phase for $0.75 \le x \le 0.92^{1,2}$ whilst for x > 0.92 the ideal cubic perovskite structure is distorted to the orthorhombic phase with lower symmetry.^{3–5} In the orthorhombic phase with x > 0.92, the *d* orbital overlap is reduced compared to the cubic phase, leading to a reduction in carrier mobility. In addition, the transition from the cubic to the orthorhombic phase has a negative effect on photocatalytic activity: photocatalytic activity for the rate of H₂ production reached a maximum at x = 0.92 and reduced for x > 0.92 in the distorted orthorhombic phase,³ indicating that Sr fractions approximately equal to 0.9 are most suitable for photocatalysis. Monophasic strontium niobate can be easily synthesised via calcination for Sr content between $0.7 \le x \le 0.97.^3$

Glancing Angle Spray Deposition



Fig. S1. Glancing angle spray deposition experimental setup. (a) Photograph of the valve driver to control the spray deposition, (b) photograph of the vacuum chamber and the solution feed, (c) photograph of the stage and substrate and (d) schematic diagram of the glancing angle spray deposition.

Laser fragmentation

(a)



Fig. S2. Laser fragmentation experimental setup. (a) Photograph of fs-laser system (b) photograph of rotating sample holder with glass vial and (c) schematic diagram of the experimental setup.

Material Characterisation

UV-Vis Tauc Plot



Fig. S3. Tauc plot for as-prepared as-prepared (a) and fragmented (b) $Sr_{0.9}NbO_3$ nanoparticles, prepared by drop-casting on quartz.



Fig. S4. Determination of the Fermi level of Sr_{0.9}NbO₃. (a) Photograph of the sample measured, with the scanned area highlighted in light grey, and the area used to calculate the Fermi level is highlighted in purple. (b) Kelvin probe measurement where the average Fermi level measured was -5.216 eV relative to the vacuum level, with a standard deviation of 0.00743.

Kelvin Probe

Solar Cell Device Characterisation

Hysteresis Analysis

Hysteresis in J-V scans is usually indicative of ionic motion, which is well observed for organometal trihalide perovskite solar cells^{6–8} and inorganic trihalide perovskite solar cells.⁹ Usually a change in scan direction and/or a change in scan rate results in a significant change in device performance, i.e. the rate at which the voltage is changed influences the J-V measurement, usually due to ionic motion^{10–12} and leads to a change in the performance parameters.

We measured J-V character for a very large range of scan rates from 150 mV/s to 1500 mV/s and do not observe any hysteresis (Fig. S5). This clearly suggests that ionic conduction or vacancy/defect migration is absent, the structure is stable and domains are not easily polarised. These features point towards a highly stable photovoltaic material and indicate that Sr/O vacancies are not migrating under applied bias, whilst the photocurrent observed is not due to a polarization effect.



Fig. S5. J-V characteristic measured in the reverse scan direction for varying scan rates between 150 mV/s (0.01 V step size, 71 points) and 1500 mV/s (0.1 V step size, 8 data points).

Comparison with reference device J-V



Fig. S6. Current density-voltage (J-V) characteristic for the reference cell compared with Sr_{0.9}NbO₃ device, both in the dark and under illumination.

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