



## Seminar announcement

Tuesday, October 24, 2023

4 pm

WSI, Seminar room S 101

### **“Developing scalable routes to photocatalytic coatings; Exploring the chemical vapour deposition of metal oxide- based materials for NO<sub>x</sub> remediation and solar water splitting”**

**Abstract:** For any technology to be translated from the laboratory to industry, the fabrication process should be inherently scalable and its components should be economical. In the Solar Coatings Group, we are focussed on developing scalable synthetic routes to photocatalytic materials, which can enable their uptake by industry. We are working on a number of technologies, and the focus of this talk will be on two of them: (i) photocatalytic coatings for window glass that can remediate surrounding NO<sub>x</sub> pollution using ambient light and (ii) photocatalytic coatings for photoelectrochemical devices that can split water and produce clean H<sub>2</sub> fuel from sunlight. In both cases we are producing materials on the 50 cm<sup>2</sup> scale using chemical vapour deposition (CVD) (Figure 1a); a technique used widely by industry to grow coatings at scale with nanoscale control. These two aspects of my talk are summarised below:

#### NO<sub>x</sub> pollution

NO<sub>x</sub> (NO + NO<sub>2</sub>) pollution is a major cause of poor health, and has a range of detrimental environmental consequences [1]. NO<sub>x</sub> pollution can be remedied by photocatalysis using TiO<sub>2</sub>, which can use ambient light to oxidise this toxin into the comparatively benign nitrate (NO<sub>3</sub><sup>-</sup>) [2]. Photocatalytic coatings of TiO<sub>2</sub> are mass produced on window glass using chemical vapour deposition (CVD), but currently show nominal activities towards NO<sub>x</sub> remediation [3].

In this section of my talk, I will present how we used aerosol-assisted CVD (AA-CVD) to produce ~50 unique TiO<sub>2</sub> coatings on window glass by systematically varying the process parameters. The coatings produced showed wide ranging physicochemical properties, including differences in phase composition (anatase/ anatase: rutile composite), optical bandgap energy, surface roughness, charge carrier generation and charge carrier lifetime. Their photocatalytic activities towards NO gas was measured using ISO protocol (ISO 22197-1:2016) [4], and the observed relationships between the processing parameters, the physicochemical properties and photocatalytic activity are discussed.

#### Water splitting

Current H<sub>2</sub> demands are vast, with the industry valued in excess of \$150 billion. Today, most H<sub>2</sub> is produced from the non-renewable reformation of natural gas, and accounts for ~3% of total CO<sub>2</sub> emissions. Various renewable methods of producing H<sub>2</sub> are being developed, with solar-driven photoelectrochemical (PEC) water splitting seen as one of the most promising routes in terms of efficiency and potential cost [5].

Bismuth vanadate (BiVO<sub>4</sub>) has emerged as one of the most PEC materials in water splitting devices. State-of-the-art systems have achieved solar-to-hydrogen (STH) efficiencies above 8%; nearing benchmark efficiencies for commercial viability [6].

In this talk, I will present the work we have done in my group on the development of scalable AA-CVD routes to high performance BiVO<sub>4</sub>-based photoanodes (Figure 1b). I will also show how the intrinsic charge carrier behavior in these photoanodes was studied using time-resolved optical spectroscopies to reveal the kinetics of water oxidation, and provide insight on the reaction mechanism. And lastly, I will present our work on developing prototypes, incorporating these BiVO<sub>4</sub>-based PECs into custom made reactors (Figure 1c).

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