JULY 07, 2020
CONFERENCE
ONLINE

Graphene Online &2DM
Fundamental Research Insights

GO 2020

MANCHESTER 1824
The University of Manchester

Anatase TiO_2 Nanosheets with Enhanced Catalytic Properties

GRAPHENE NOWNANO CDT

Marco Zarattini[a], *Chaochao Dun*[b], *Liam H. Isherwood*[a,d], *Linfei Zhang*[c], *Xiuju Song*[a], *Alexandre Felten*[e], *Jeffrey J. Urban*[b], *Wenjing Zhang*[c], *Aliaksandr Baidak*[a,d], *Robert Ionescu*[f], *Jarrid A. Wittkopf*[f], *Helen Holder*[f], *and Cinzia Casiraghi*[*a]

[a]Department of Chemistry, University of Manchester, Oxford Road, Manchester, United Kingdom, M13 9PL, [b]The Molecular Foundry, Lawrence Berkeley National Laboratory, Berkeley, California 94720, United States, [c]College of Computer Science and Software Engineering, Shenzhen University, Shenzhen, China, [d]Dalton Cumbrian Facility, University of Manchester, Westlakes Science and Technology Park, Moor Row, Cumbria, United Kingdom, CA24 3HA, [e]Physics Department, Université de Namur, Rue de Bruxelles, Namur, Belgium, [f]HP Laboratories, 1501 Page Mill Road, Palo Alto, California 94304, United States

INTRODUCTION

Titanium oxide (TiO_2)

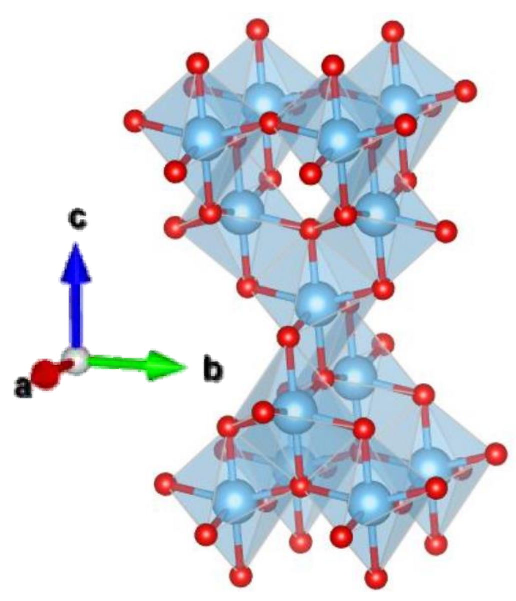
- Oxide of Titanium (Titania) that belongs to the family of Transition metal oxides

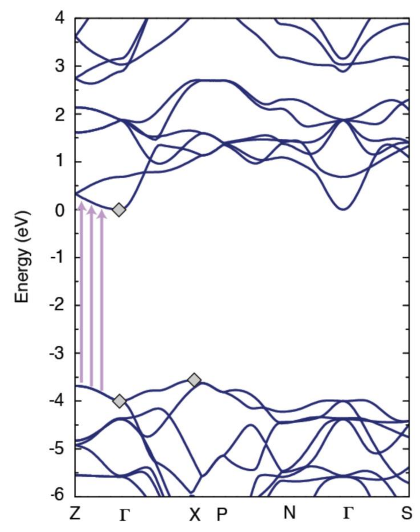
Graphene family	Graphene	hBN 'white graphene'	BCN	Fluorographene	Graphene oxide
2D chalcogenides	MoS_2, WS_2, $MoSe_2$, WSe_2	Semiconducting dichalcogenides: $MoTe_2$, WTe_2, ZrS_2, $ZrSe_2$ and so on	Metallic dichalcogenides: $NbSe_2$, NbS_2, TaS_2, TiS_2, $NiSe_2$ and so on	Layered semiconductors: GaSe, GaTe, InSe, Bi_2Se_3 and so on	
2D oxides	Micas, BSCCO	MoO_3, WO_3	Perovskite-type: $LaNb_2O_7$, $(Ca,Sr)_2Nb_3O_{10}$, $Bi_4Ti_3O_{12}$, $Ca_2Ta_2TiO_{10}$ and so on	Hydroxides: $Ni(OH)_2$, $Eu(OH)_2$ and so on	
	Layered Cu oxides	TiO_2, MnO_2, V_2O_5, TaO_3, RuO_2 and so on		Others	

[1]

- Wide band gap semiconductor (>3 eV) that exists in different polymorphs.
- Common investigated structures: Anatase, Rutile, Brookite and TiO_2(B).
- Low cost, chemical stability, nontoxicity, multifunctionalities in catalysis, photocatalysis, electronics, photovoltaic and biomedical application [2].
- anatase -- the best photoactive reactivity in catalytic applications [3].

Anatase TiO_2 crystal structure and EBS

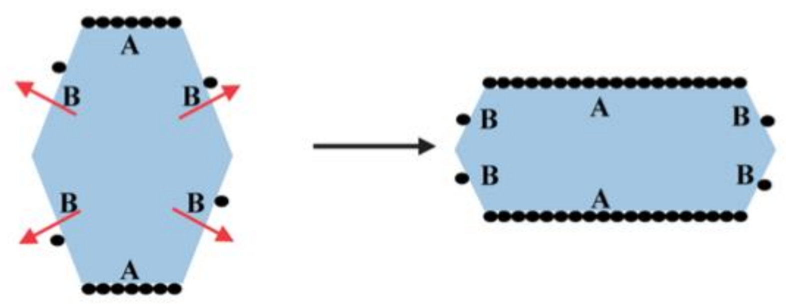




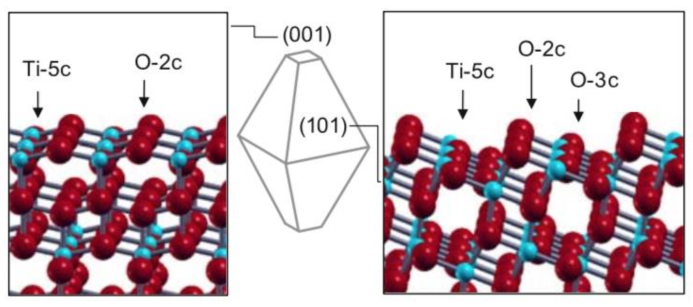
[4]

STATE OF ART

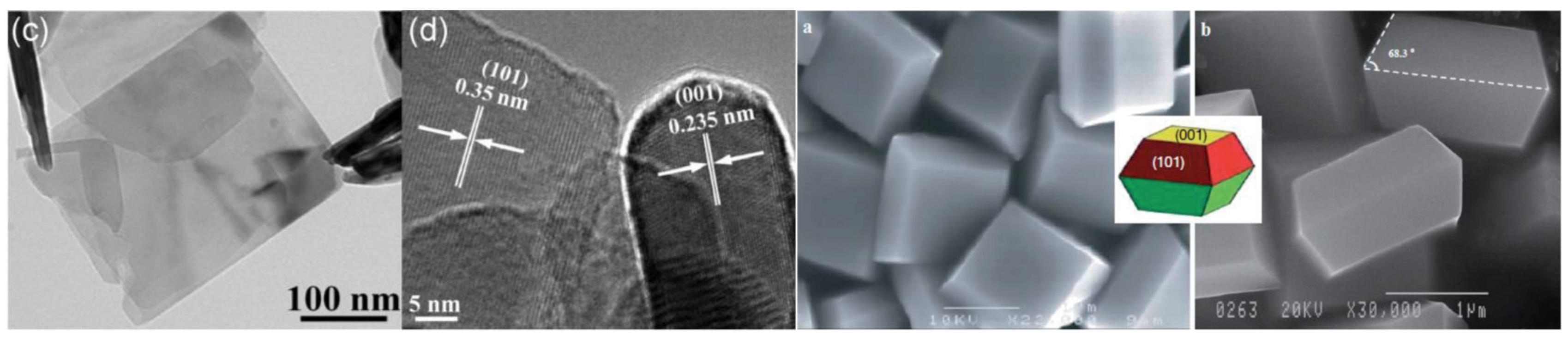
- TiO_2 doesn't belong to the Van der Waals materials family, so its 2D counterpart cannot be produce as Graphene or TMDs via liquid-phase exfoliation but needs others synthetic routes
- Hydrofluoric acid (HF) is currently used as capping agent during hydrothermal reaction for the fabrication of 2D Anatase TiO_2 with high exposure of [001] facets [5].



[6]



- Fluorinated 2D crystals can reach up to 70% of exposed [001] facets with thickness below 2nm showing the best photocatalytic activity (several times than P25).

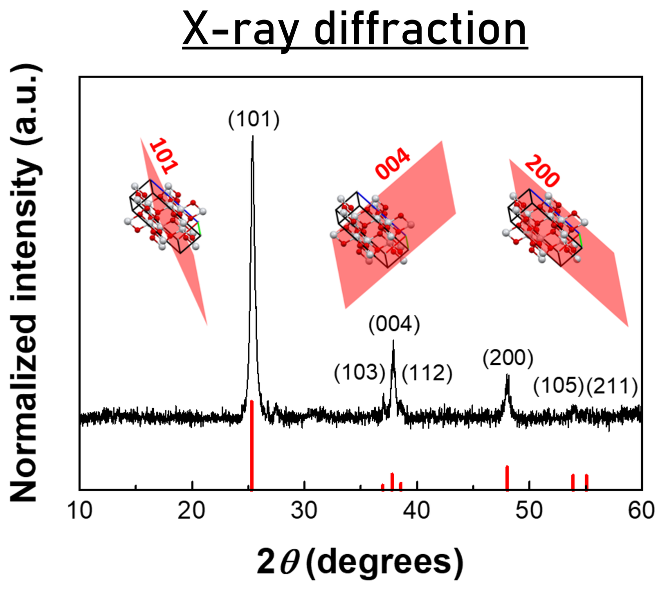


[7]

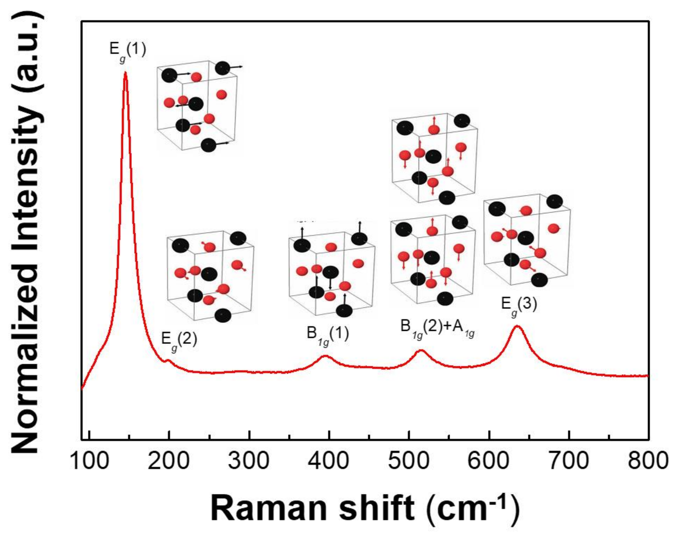
- The described process in literature is effective and relatively fast but it needs the employment of **HF** that is known to be **highly corrosive** and **toxic**.
- **In this project** we used a novel **fluorine-free bottom up strategy** for the shaping of two-dimensional anatase Titanium oxide without the needs of any harmful reagents. We have used two synthetic process, but the details of the synthesis **cannot be disclosed due to the industrial nature of the project**.

RESULTS

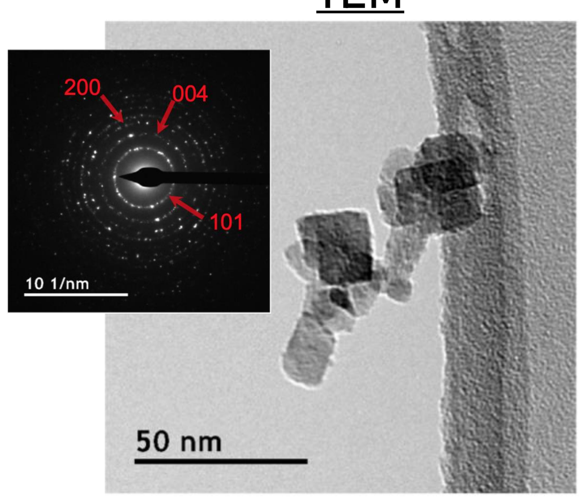
X-ray diffraction



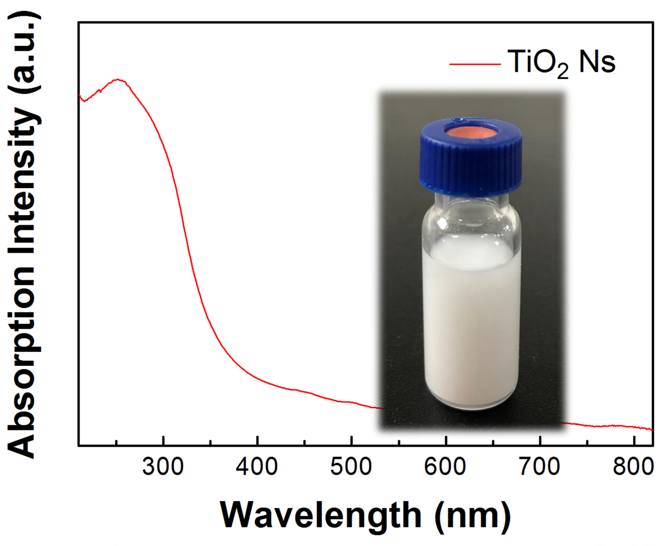
Raman spectroscopy



TEM

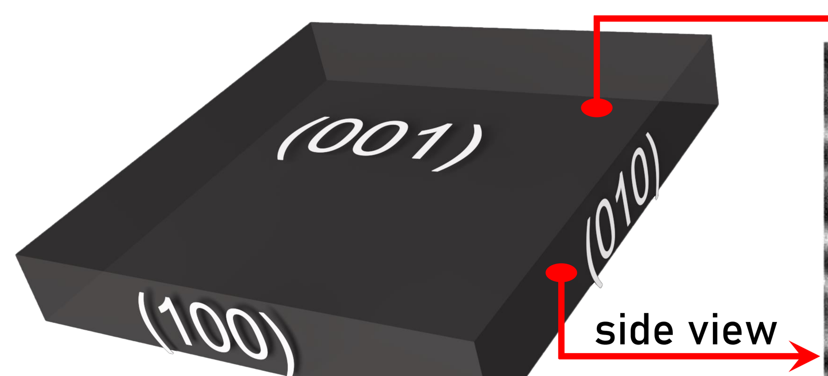


UV-Visible

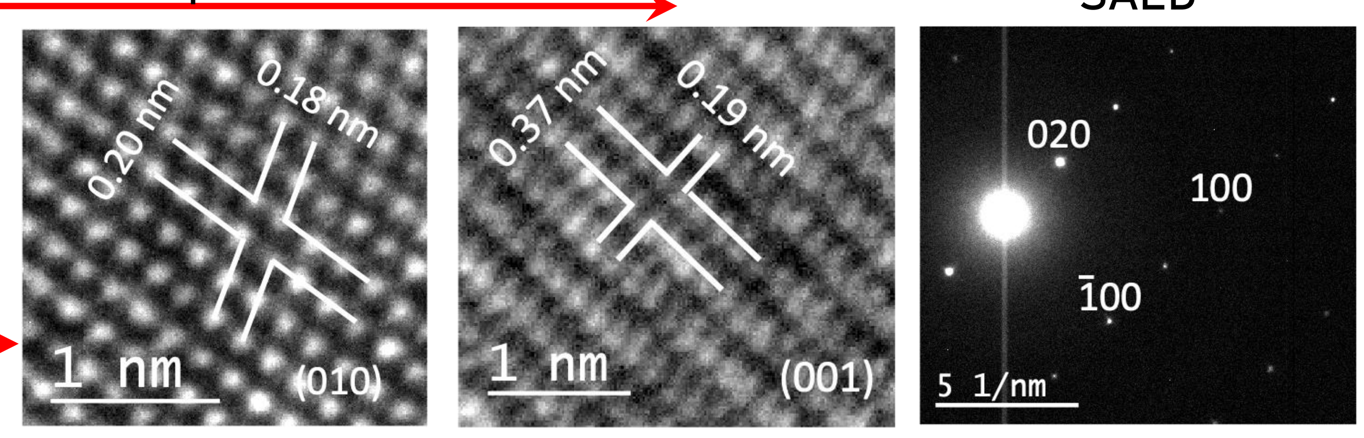


Anatase TiO_2 nanosheets were successfully achieved allowing high crystalline thin flakes. Final material was fully characterized by the use of Raman spectroscopy, Transmission electron microscopy and UV-Vis confirming typical Anatase characteristics.

2D facets exposed

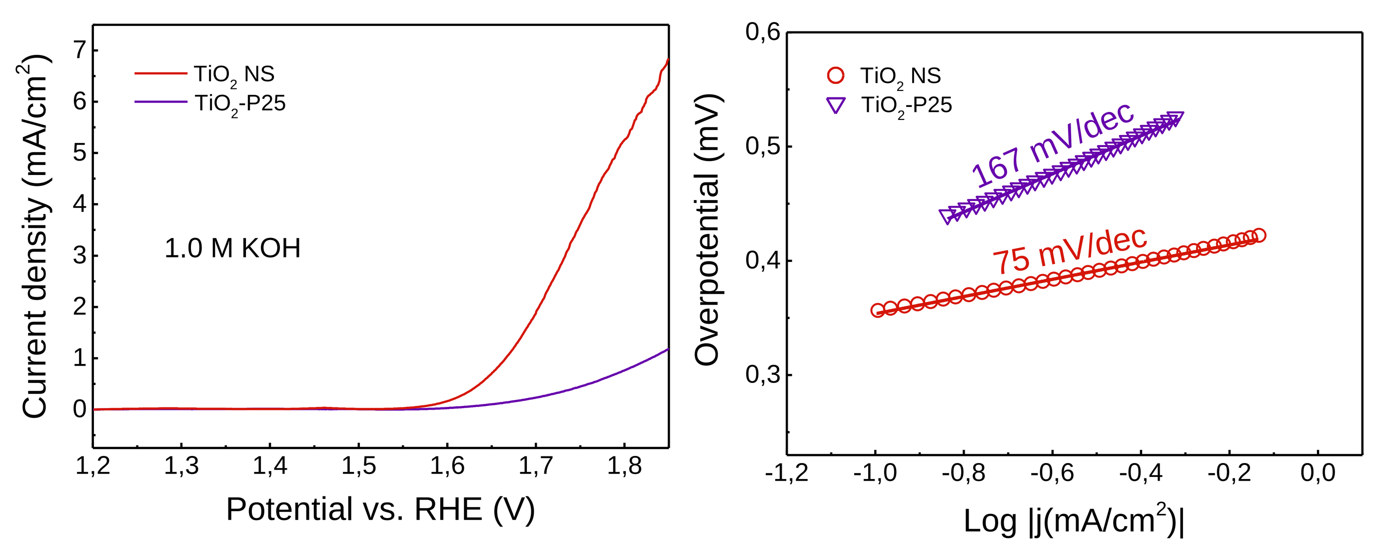


High-resolution TEM



2D anatase TiO_2 are single crystalline exposing high percentage of high energy facets (001) and lateral (100) and (010). This unique 2D morphology permitted enhanced catalytic properties for oxygen evolution reaction in alkaline conditions outperforming commercial anatase TiO_2 nanoparticles.

Oxygen evolution reaction (OER) performances



CONCLUSIONS

- 2D anatase TiO_2 were successfully produced. Morphology and crystallinity were evaluated and confirmed by structural analysis. As-fabricated 2D TiO_2 are enclosed by high energy facets (001), (100) and (010)
- 2D anatase TiO_2 showed enhanced electrocatalytic properties for oxygen evolution reaction (OER)

CONTACT PERSON

Marco Zarattini

marco.zarattini@postgrad.manchester.ac.uk

REFERENCES

[1] A.K. Geim, I. Grigorieva, *Nature*, 2013, 499, 7459
[2] L. Wang et. al, *Chemical Reviews*, 2014, 114, 9455
[3] W.J. Ong et. al, *Nanoscale*, 2014, 6, 1946
[4] E. Baldini et. al, *Nature Communications*, 2017, 8, 13
[5] H. Yang et. al, *Nature*, 2008, 453, 638
[6] W.J. Ong et. al, *Nanoscale*, 2014, 6, 1946
[7] L. Wang et. al, *Chemical Reviews*, 2014, 114, 9455

Graphene Online &2DM
Fundamental Research Insights
GO 2020