Supporting Information

2D vanadium oxide Inverse Opal：cycling stability exploration as electrochromic active electode

Hua Li[a,*], Yuwei Liu[a], Weihui Jiang[c], Jian Liang[c], Zijuan Tang[a], Meilin Hu[a], Jacques Robichaud[b], Yahia Djaoued[b,*]

a Department of Materials Chemistry, School of Materials Science and Engineering, Jingdezhen Ceramic University, Jingdezhen, Jiangxi, 333403, PR China, Tel: +86 798 8499678, E-mail: 201002@jci.edu.cn;

b Laboratoire de Recherche en Matériaux et Micro-spectroscopies Raman et FTIR, Université de Moncton-Campus de Shippagan, Shippagan, NB, E8S1P6, Canada. Fax: +1 506 336 3434; Tel: +1 506 336 3412; E-mail: Yahia.djaoued@umoncton.ca;

c National Engineering Research Centre for Domestic & Building Ceramics, Jingdezhen Ceramic Institute, Jingdezhen, Jiangxi, 333001, PR China, Tel: +86 798 8499328 ，E-mail: whj@jci.edu.cn;

Figures

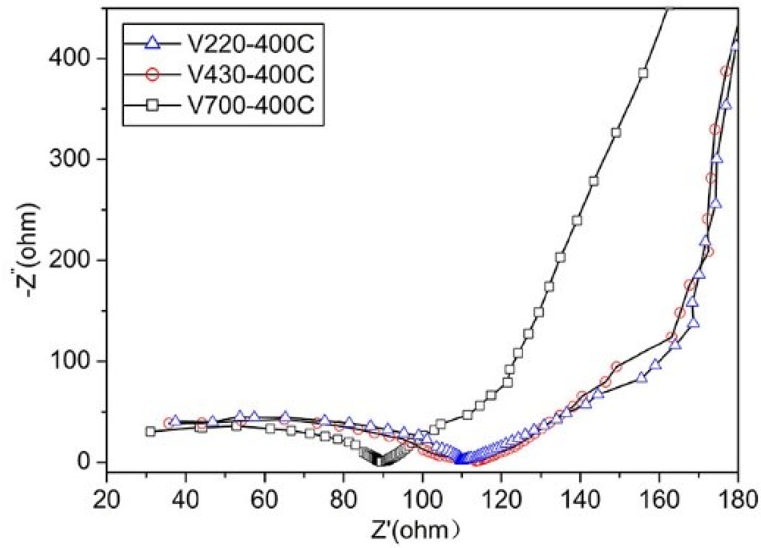
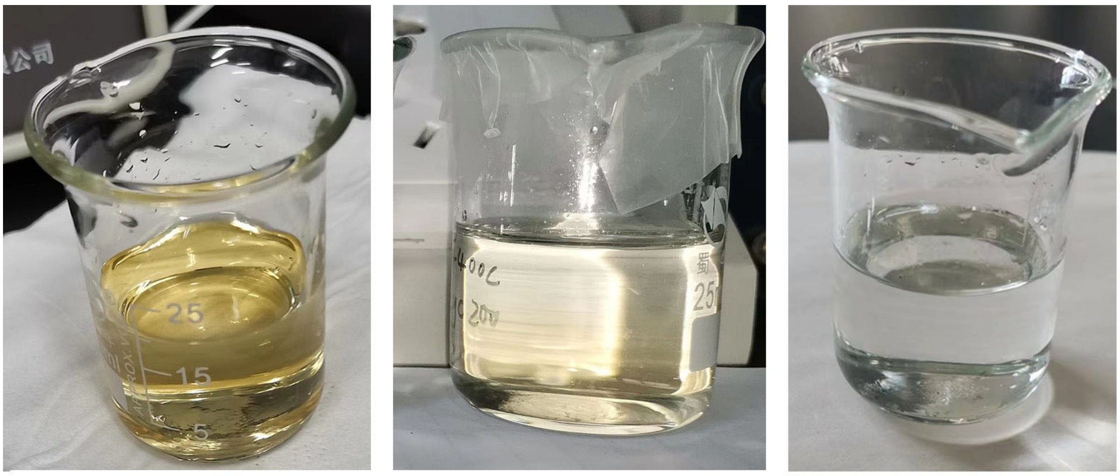


Figure S1 Impedance spectra of V220-400C (blue, triangle), V430-400C (red, circle) and V700-400C (black, square) samples.



V430-400C V220-400C AV430-400C

Figure S2 Electrolyte solution color after electrochromic cycled for 200 times with various vanadium oxide IO as electrochromic active electrode: V430-400C (left), V220-400C (middle) and AV430-400C (right).

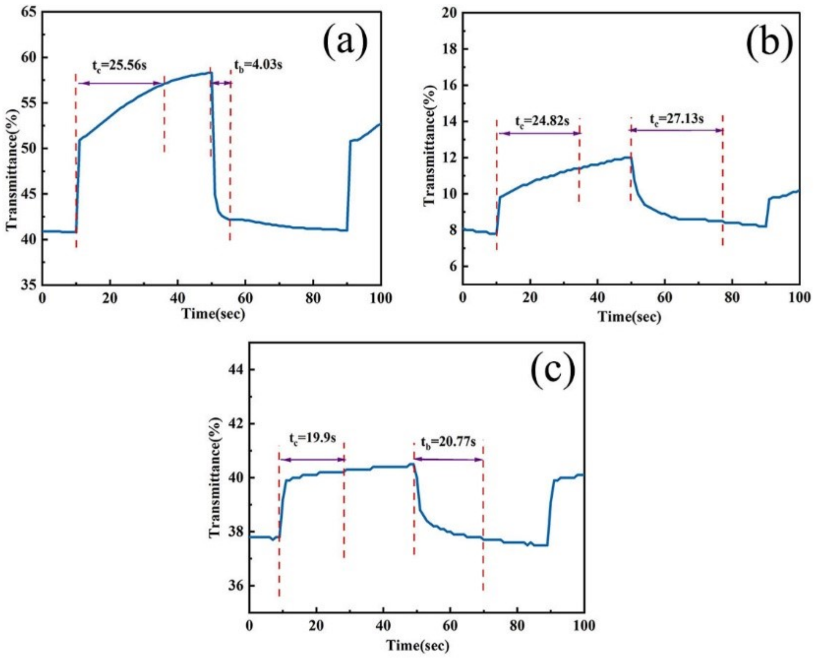


Figure S3 Time dependent transmittance curves of the ECDs in the 4th cycle for V220-400C (a), V430-400C (b) and AV430-400C (c).

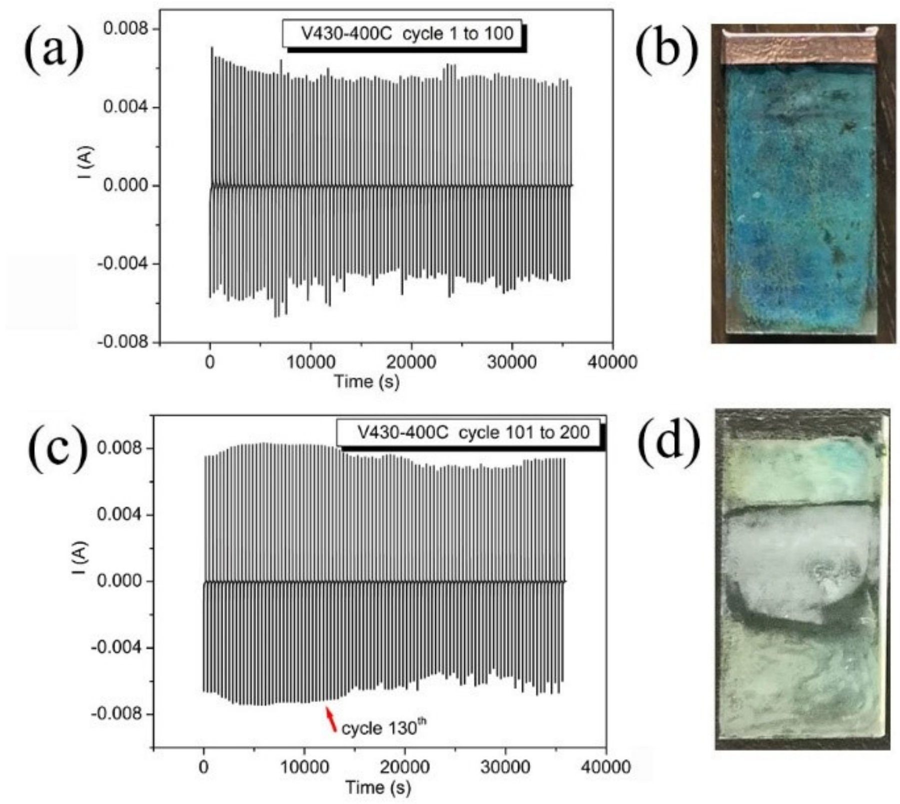


Figure S4 Room temperature chronoamperometry (CA) and corresponding optical photos of V430-400C after cycling 100 times (a, b) and 200 times (c, d).

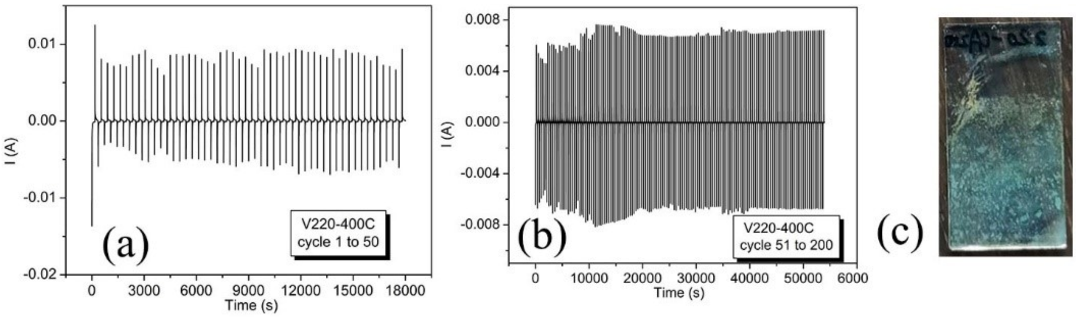


Figure S5 Room temperature chronoamperometry (CA) of V220-400C after 50 (a) and 200 (b) cycles, and corresponding optical photo of the film after 200 cycles (c)

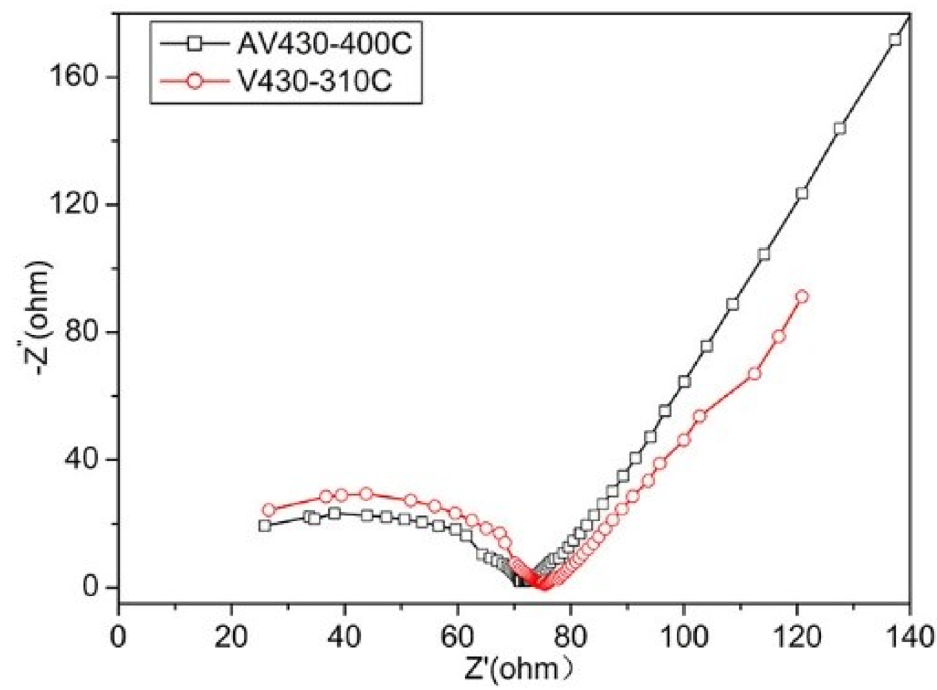


Figure S6 Impedance spectra of AV430-400C (black, square) and V430-310C (red, circle) samples.

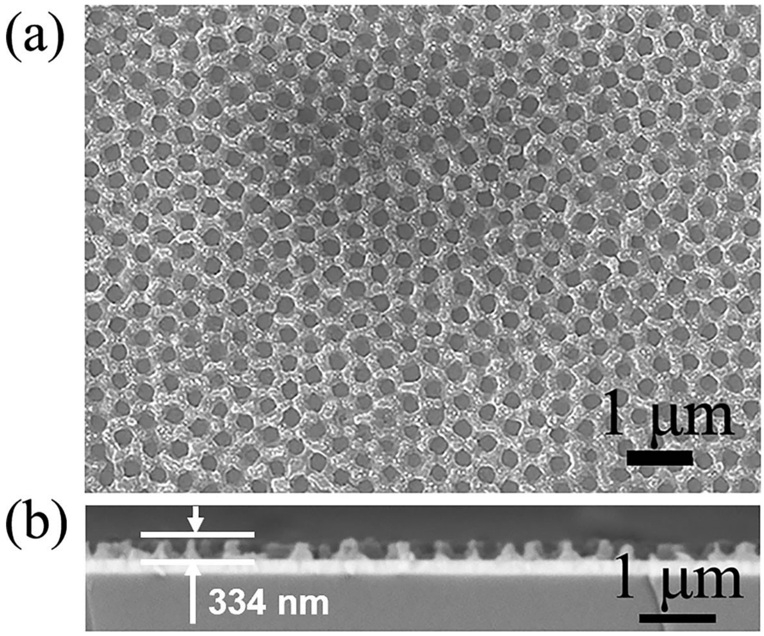


Figure S7 SEM (a) and cross-sectional (b) images of sample AV430-400C.

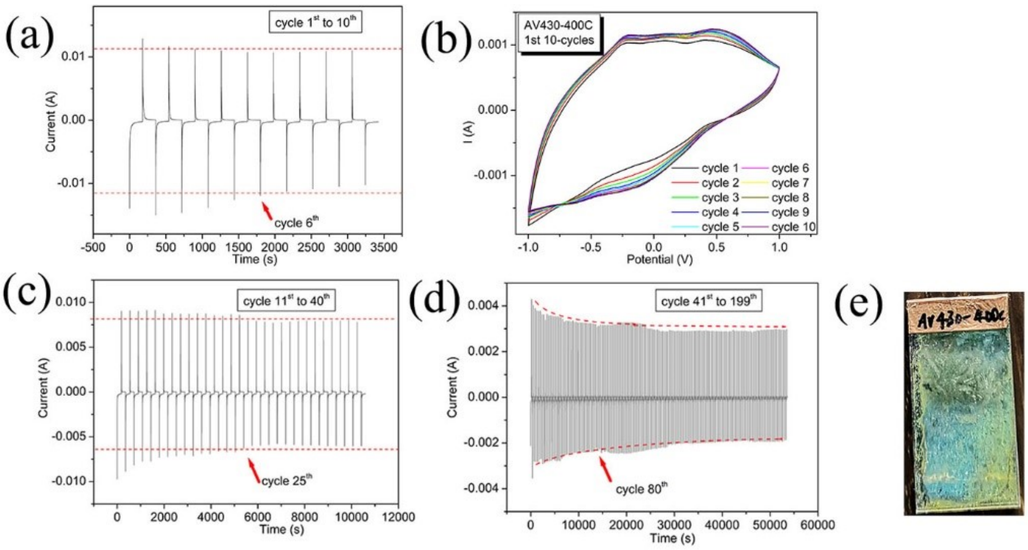


Figure S8 Room temperature chronoamperometry (CA) after cycling 10 times (a) 40 times (c) and 200 times (d), room temperature cycling voltammetry for the first 10 cycles (b), and the optical photo after 200 cycles (e) for AV430-400C sample

Tables

Table S1 Values of Optical density and stability in literature

V_2O_5	Film thickness (nm)	ΔOD/Wavelength[a]	stability	devices	Ref
Dense film	1100	0.07/650nm	/	$ITO/V_2O_5/LiClO_4/Pt$, -0.5 V to +0.5 V	S1
3DOM (pore size 210nm)		0.33/650nm			
3DOM (pore size 340nm)		0.28/650nm			
planar film	200-700	0.14/600nm	0.13/60000cycles[b]	$ITO/V_2O_5/LiClO_4/Pt$, -1.2 V to 1.4 V	S2
planar film	265	0.19/633nm	~80 % /140 cycles[c]	$FTO/V_2O_5/LiClO_4/Ag$, -0.85 V to +0.85 V	36
planar film	450	0.13/550nm	/	$ITO/V_2O_5/LiClO_4/Pt$, -0.75 V to +0.85 V	37
planar film	80	0.15/560nm	~50 %/100 cycles[c]	$SnO_2/V_2O_5/LiClO_4/Pt$, -1.5 V to +1.0 V	38
xerogel film	250	0.21/700nm	/	$FTO/V_2O_5/LiClO_4/Pt$, -2.7 V to +3.0 V	S3
planar film	/	0.14/630nm		$FTO/V_2O_5/LiClO_4/FTO$,	39
Nanorod film	/	/	7.5 %/700 nm/100cycles[d]	$ITO/V_2O_5/LiClO_4/Pt$, -0.7 V to +1.0 V	S4
Nanosheets film	40	/	65 %/100 cycles[c]	$PET/ITO/V_2O_5/LiClO_4/Pt$, -1 V to +1 V	S5
SnO_2/V_2O_5	200	/	86 %/450 nm/2000 cycles[d]	$ITO/V_2O_5/LiClO_4/Pt$, -1 V to +1.8 V	53
V_2O_5			10%/450 nm/300 cycles[d]		
planar film	/	/	46 %/100 cycles[c]	$V_2O_5/LiClO_4/Pt$, -1.5 V to +1 V	S6
nanosheet	/	/	68 %/300 cycles[c]	/	S7
nanobelts	/	/	39 %/80 cycles	$V_2O_5/LiNO_3/Ni$ -0.4 V to +0.8 V	S8

[a], optical density (OD) for the 1st cycle

[b], optical density (OD) for certain cycles

[c], electrochemical capacity retention

[d], optical contrast retention

References：

[S1] Z. Tong, J.Hao, Zhang K., J. Zhao, B.-L. Su, Y. Li, Improved electrochromic performance and lithium diffusion coefficient in three-dimensionally ordered macroporous V_2O_5 films, *J. Mater. Chem. C*, 2014, **2(18)**, 3651-3658.
[S2] G. J. Fang, Z. L. Liu, Wang Y. Q., , H. H. Liu, K. L. Yao, Orientated growth of V_2O_5 electrochromic thin films on transparent conductive glass by pulsed excimer laser ablation technique, *J. Phys. D*, 2000, **33(23)**, 3018.
[33] C. M. Cholant, T. M. Westphal, R. D. C. Balboni, E. A. Moura, A. Gündel, W. H. Flores, A. Pawlicka, C. O. Avellaneda, Thin films of V_2O_5/MoO_3 and their applications in electrochromism, *J. Solid State Electr.*, 2017, **21(5)**, 1509-1515.
[34] C. O. Avellaneda, Electrochromic performance of sol-gel deposited V_2O_5: Ta films, *Mater. Sci. Eng. B*, 2007, **138(2)**:118-122.
[35] M. Panagopoulou, D. Vernardou, E. Koudoumas, D. Tsoukalas, Y. S. Raptis, Tungsten doping effect on V_2O_5 thin film electrochromic performance, *Electrochim. Acta*, 2019, **321**, 134743..
[S3] S. Surendren, B. Deb, Studies on spontaneously reduced vanadium pentoxide xerogel coatings for electro-chromic applications[J]. *Electrochim. Acta*, 2021, **389**: 138629.
[36] C. E. Patil, P. R. Jadhav, N. L. Tarwal, H.P. Deshmukh, M.M. Karanjkar, P.S. Patil, Electrochromic performance of mixed V_2O_5–MoO_3 thin films synthesized by pulsed spray pyrolysis technique, *Mater. Chem. Phys.*, 2011, **126(3)**, 711-716..
[S4] W. Kang, C. Yan, X. Wang, C. Y. Foo, A. W. Ming Tan, K. J. Zhi Chee, P. S. Lee, Green synthesis of nanobelt-membrane hybrid structured vanadium oxide with high electrochromic contrast, *J. Mater. Chem. C*, 2014, **2**, 4727–4732
[S5] Y. Qi, K. Qin, Y. Zou, L. Lin, Z. Jian，W. Chen, Flexible electrochromic thin films with ultrafast responsion based on exfoliated V_2O_5 nanosheets/graphene oxide via layer-by-layer assembly, *Appl. Surf. Sci.*, 2020, **514**, 145950
[50] G. Zhao, W. Wang, X. Wang, X. Xia, C. Gu, J. Tu, A multicolor electrochromic film based on a SnO_2/V_2O_5 core/shell structure for adaptive camouflage, *J. Mater. Chem. C*, 2019, **7(19)**, 5702-5709.
[S6] M. Panagopoulou, D. Vernardou, E. Koudoumas, Tunable properties of Mg-doped V_2O_5 thin films for energy applications: Li-ion batteries and electrochromics, *J. Phys.Chem. C*, 2017, **121(1)**, 70-79.
[S7] X. Wang, Y. Li, S. Wang, F. Zhou, P. Das, C. Sun, S. Zheng, Z. Wu, 2D amorphous V_2O_5/graphene heterostructures for high-safety aqueous Zn-ion batteries with unprecedented capacity and ultrahigh rate capability, *Adv. Energy mater.*, 2020, **10(22)**, 2000081.
[S8] Y. Zhao, J. Zheng, Y. Zhao, T. Hu, Z. Gao, C. Meng, Fabrication of V_2O_5 with various morphologies for high-performance electrochemical capacitor, *Appl. Surf. Sci.*, 2016, **377(30)**, 385-393.