SVC PowerPoint Presentation Cover Sheet

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Effect of Interfacial Mechanical Properties on PVD/PACVD DLC Coatings

Junwei Wu, Minghua Zhao, Yali Liu, Youlin Wang
Tritree Metal (Shenzhen) Co., Ltd., Shenzhen, China
Shenzhen Senfung Vacuum Plating Co., Ltd., Shenzhen, China
Shenzhen Vacuum Society, Shenzhen, China
Shenzhen Association for Vacuum Technologies, Shenzhen, China

Diamond-like carbon (DLC) with comprehensive performance of low friction coefficient, high hardness, good abrasion resistance and high chemical stability gets wordwide excellent scientific research workers and enterprises attention. But because of the influence of DLC s preparation method and its limitation of the micro structure, its internal stress is very high and the adhesion strength is low. In order to improve bonding strength of DLC films, CrC is added as the transition layer between the film and substrate, preparation parameters and multilayer structure of CrC transition layer are researched. In order to further improve the DLC films binding strength for mechanical properties, WC transition layer was prepared by hybrid PACVD and PVD processes comparing with the traditional preparation system on the differences of structure and mechanical properties. The two interlayer studies proved that PVD interlayer played a key role in high quality DLC coating. It provides a new way for large-scale produced DLC films with low cost and excellent comprehensive properties.

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Effect of interfacial mechanical properties on PVD/PACVD DLC coatings

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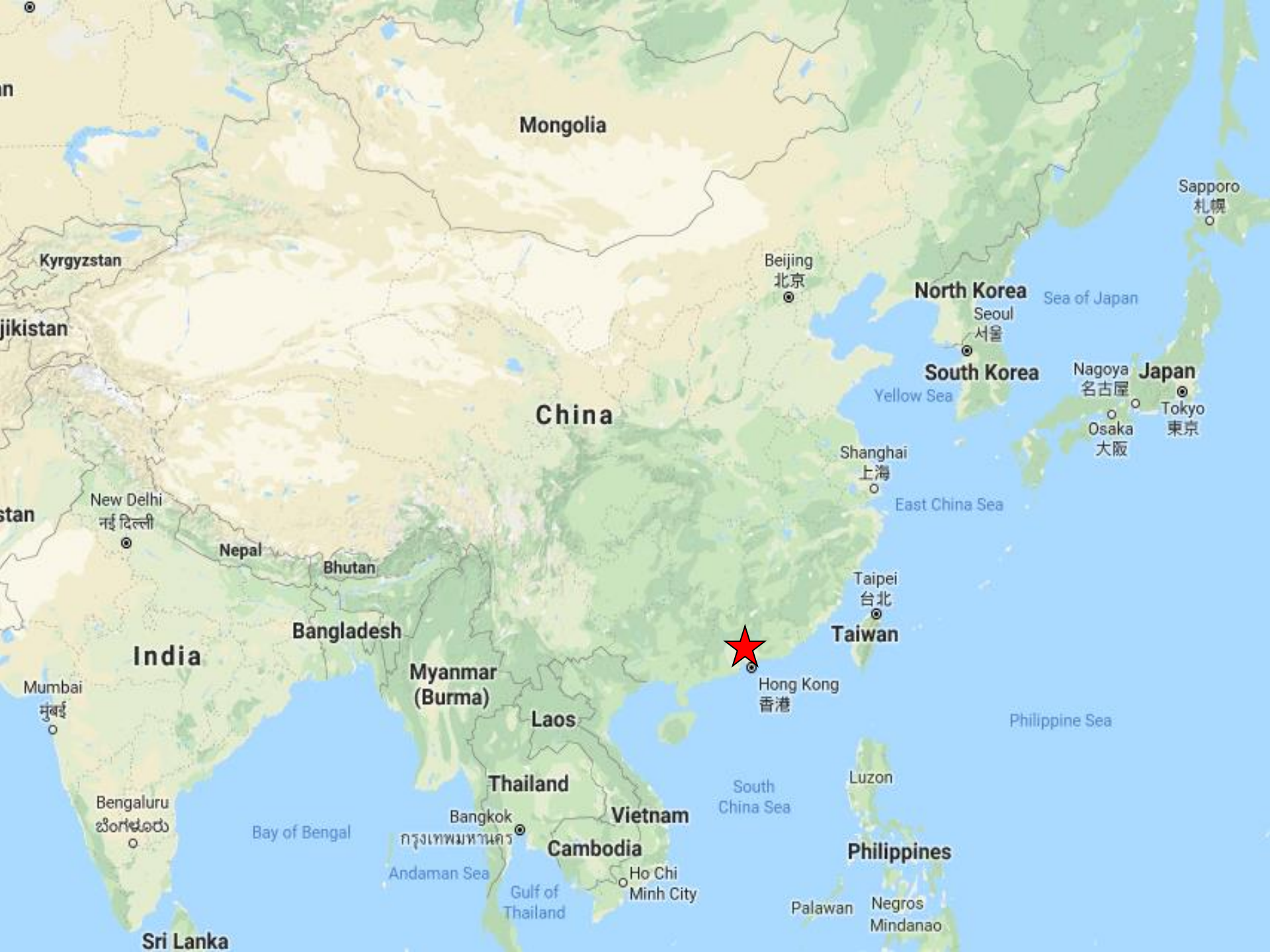
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名古屋
Japan
Tokyo
東京
Osaka
大阪
Yellow Sea
China
Shanghai
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East China Sea
New Delhi
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Nepal
Bhutan
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台北
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(Burma)
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Mumbai
मुंबई
Laos
Philippine Sea
Thailand
Luzon
South
China Sea
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Bangkok
กรุงเทพมหานคร
Vietnam
Bay of Bengal
Cambodia
Philippines
Andaman Sea
Ho Chi
Minh City
Gulf of
Thailand
Palawan
Negros
Mindanao
Sri Lanka

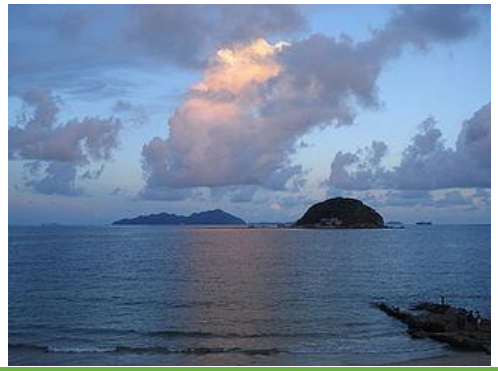
Shenzhen and Shenzhen Vacuum Industries

森科 五金
TRITREE METAL

- Shenzhen forms part of the Pearl River Delta megalopolis. The city is located immediately north of Hong Kong Special Administrative Region
- Shenzhen is home to many internationally successful high-tech companies : Huawei, Tencent, BYD
- Also, Home to vacuum related industries

  From components to chamber, and various applications

- Shenzhen Vacuum Society
- Shenzhen Vacuum Tech. Industry Asso. (Booth 124)
  - HCVAC (Booth 125, info@hcvac.com)



Two International conferences

森科 五金
TRITREE METAL

2018第三届国际（中国·深圳）
真空镀膜技术与应用研讨会暨行业展览

The 3rd international symposium and exhibitions on vacuum coating technologies and applications (Shenzhen, China 2018)

时间：November 18-19-20, 2018年11月18-19-20日

规模：800人
800 people scale

组织机构：深圳市真空技术行业协会
Organizational Unit: ShenZhen Association for Vacuum Technology Industries

应用报告征集

森科 五金

TRITREE METAL

专业的真空镀膜供应商

Professional vacuum coating supplier

- Tritree Metal Group
  - R&D Center
  - SenFung (Watches)
    - Sales Office Hong Kong
    - Manufacturing Dept. 1
    - Manufacturing Dept. 2
    - Manufacturing Dept. 3 (New plant)
  - Tritree (3C)
    - Manufacturing Dept. 4
    - Manufacturing Dept. 5 (New plant)

Decorative Coatings

森科 五金
TRITREE METAL

Gun，
Titanium
Gray, Black

Blue, Brown, Coffee, Purple

Gold

Black

Rose Gold

Colorful

Imation Gold

Customized color

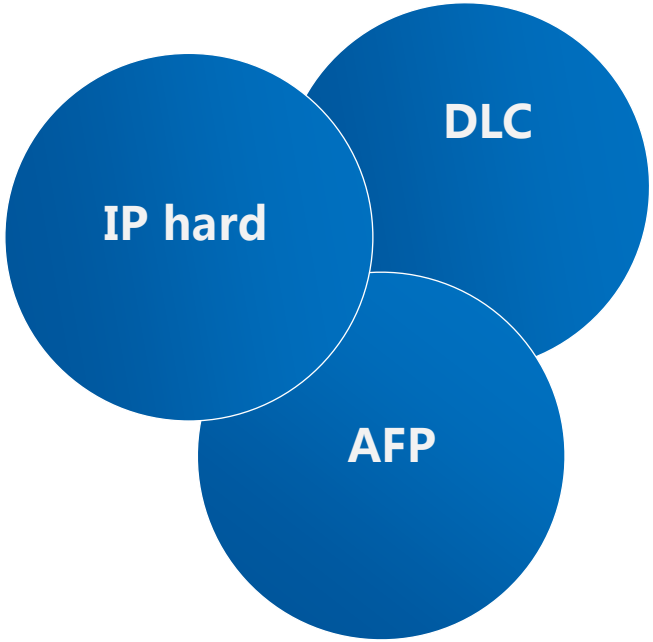
IP Gold

Rose Gold

Lower cost, Durable

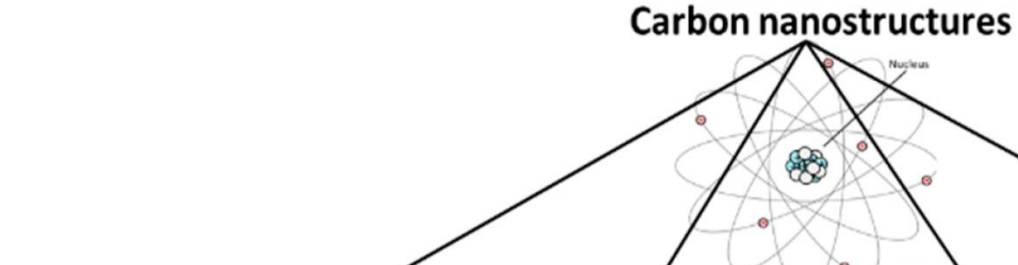
Functional coatings

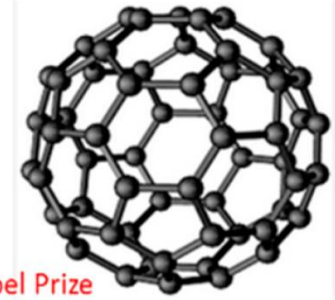
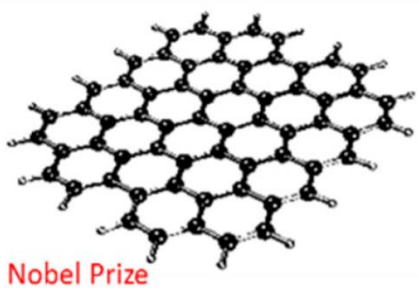
Stainless or black color,
2-5μm
>1000HV
Scratch resistant



Gray to Black
1-4μm
scratch resistant

Diamond like carbon



Fullerene	Nanotubes	Graphene	Diamond like carbon
0D	1D	2D	3D
			
Nobel Prize		Nobel Prize	
sp^2	sp^2	sp^2	sp^2/sp^3
Several structures such as C60, C70, C76, C78 and C84	Single-walled tubes Multi-walled tubes	Various forms such as Monolayer, Multilayers Nanoribbons, Quantum dots	Amorphous Hydrogenated amorphous

Fabrication methods

- **The hydrogen content affects the structure of DLC coatings and it may vary from less than 1% in non-hydrogenated DLC films to about 60% in hydroge nated DLC films.**
- **Fabrication methods**

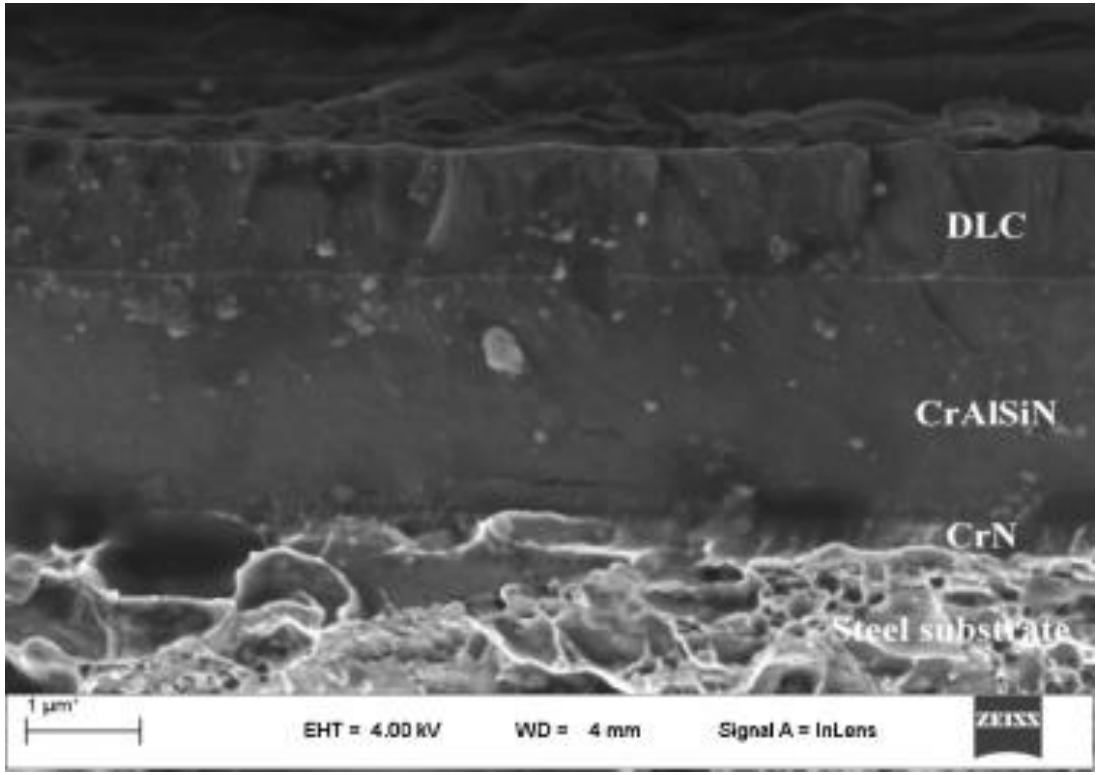
  Magnetron sputtering
  PACVD
  Cathodic Arc

The higher the hardness, the higher the stress will be

	sp^3 (%)	H (%)	Density ($g\ cm^{-3}$)	Hardness (GPa)
Diamond	100	0	3.5	100
Graphite	0	0	2.3	
Glassy C	0	0	1.3-1.5	3
Evaporated C	0	0	1.9	3
Sputtered C	5	0	2.2	
ta-C	80-88	0	3.1	80
ta-C:H	70	30	2.4	50
a-C:H hard	40	30-40	1.6-2.2	10-20
a-C:H soft	60	40-60	1.2-1.6	<10

How to achieve excellent coatings

- PVD (Magnetron sputtering) –Excellent adhesion, fine particle
- PACVD—compact DLC coatings
- **Coatings made by PVD/PACVD is a good option for decorative applications.**



Motivation: To study the effects of PVD sublayer on the DLC coatings performance

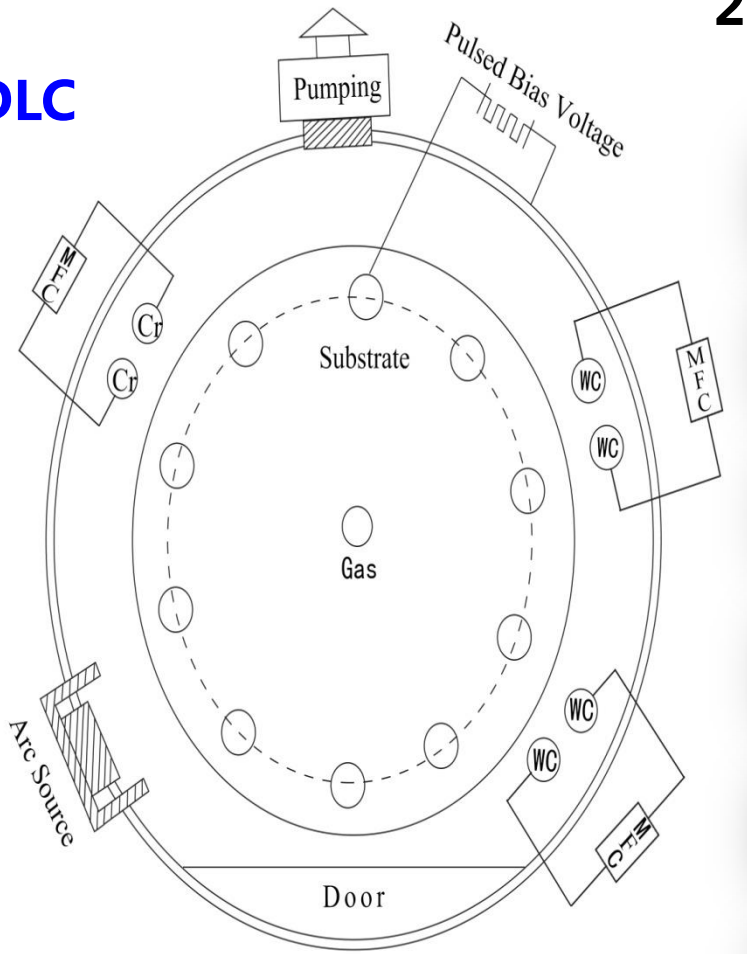
Applied Surface Science 312 (2014) 126–133

Experimental

1. Deposition

PVD CrC + PACVD DLC

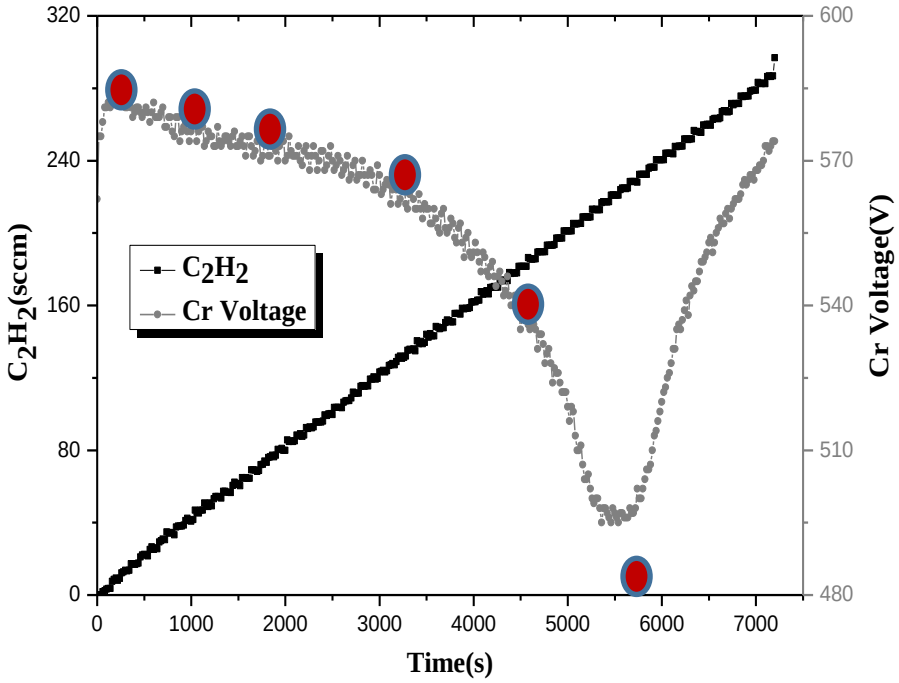
1. Ultrasonic cleaing
2. Vacuum/Heating
3. Ion cleaning
4. PVD transition layer
5. **PACVD DLC**

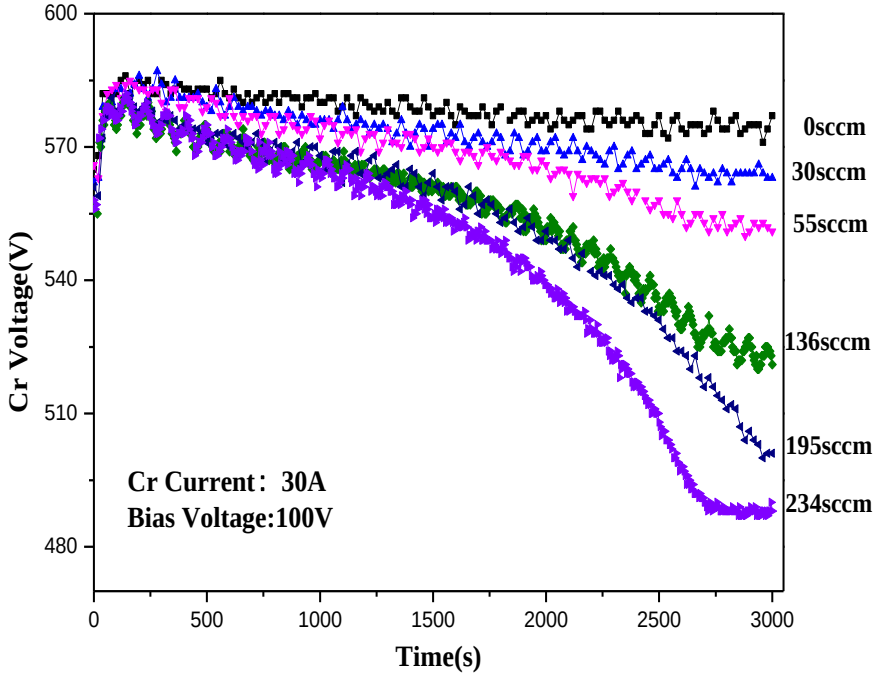


2. Characterizations

1. SEM、Raman
2. Nano hardness
3. Vickers Hardness
4. Vibration abrasion
5. Abrasion test
6. Adhesion

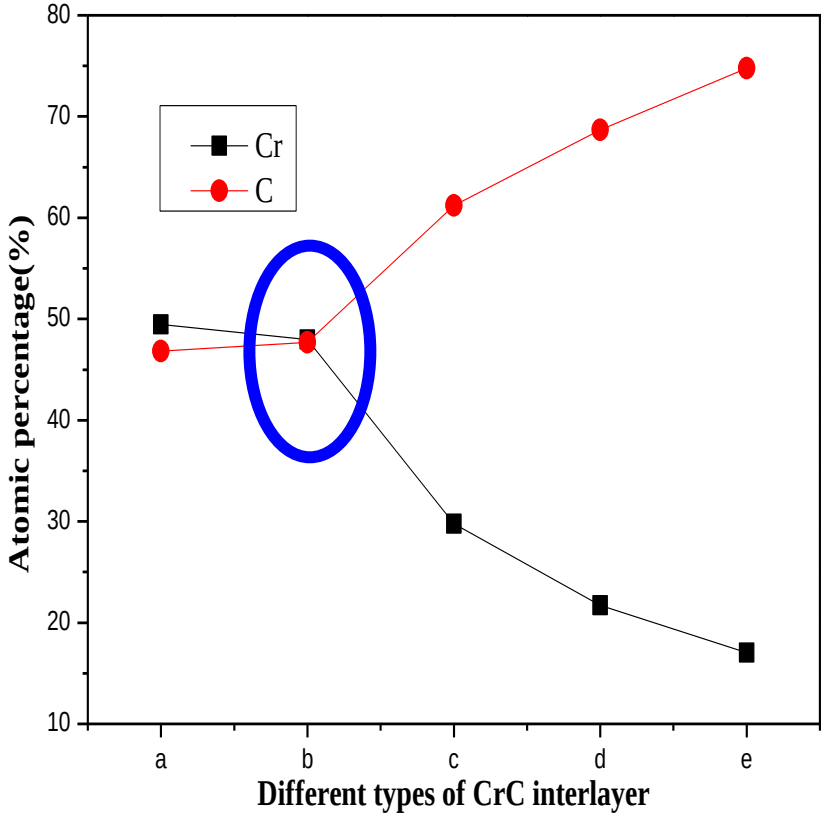
Effect of C_2H_2 content





Cr Target voltage decreases then suddenly increase with C_2H_2 content.

Effect of C_2H_2 content

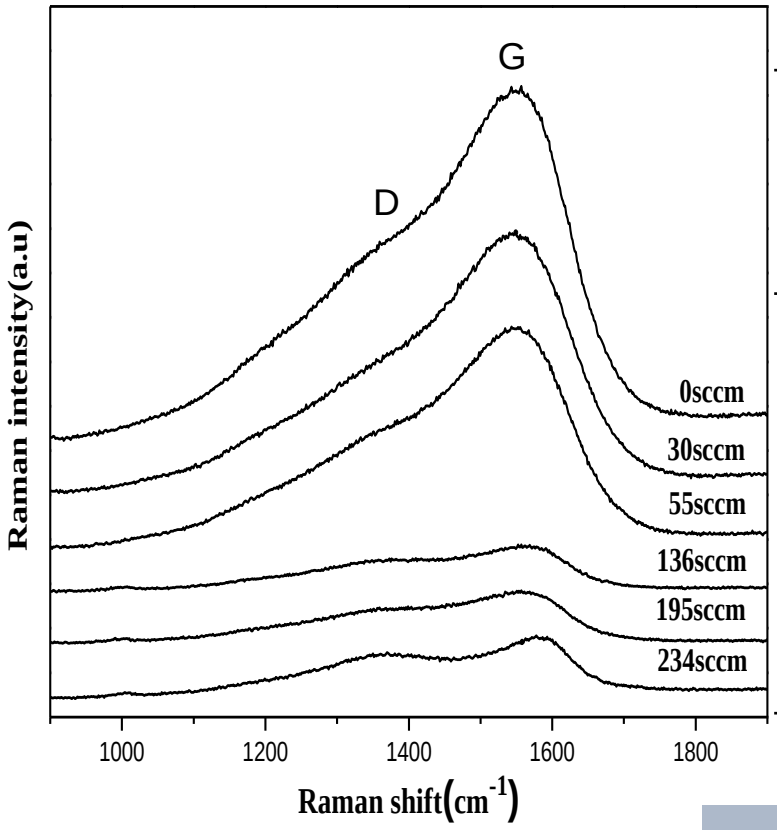


a)C_2H_2=30 sccm; b)C_2H_2=55 sccm;
c)C_2H_2=136 sccm
d)C_2H_2=195 sccm; e)C_2H_2=234 sccm

No.	Hardness/Gpa	Hardness/HV	Elastic Modulus/Gpa
1#	8.858	820.357	205.768
2#	10.374	960.745	264.916
3#	11.078	1025.946	203.624
4#	7.291	675.482	130.551
5#	6.786	621.451	110.357
6#	6.608	611.971	82.997

C_2H_2 flows 55sccm, Cr:C is 1:1, CrC has the highest hardness

Effect of C_2H_2 content

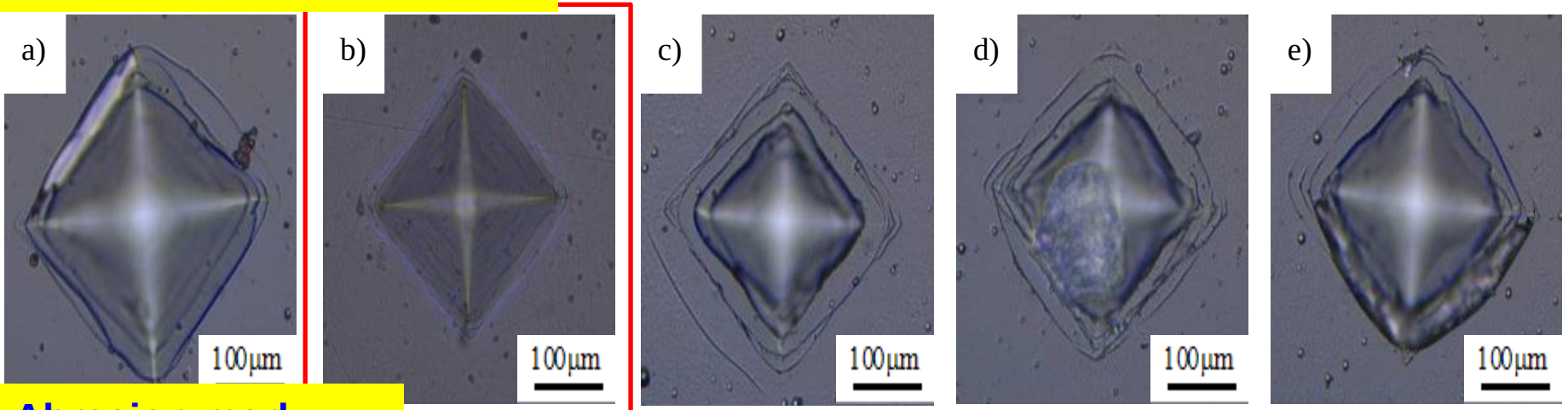


No.	C_2H_2/sccm	D peak		G peak		I_d/I_g
		Peak/cm^{-1}	FWHM/cm^{-1}	Peak/cm^{-1}	FWHM/cm^{-1}	
1#	0	1388.33	348.27	1556.46	154.52	1.73
2#	30	1390.04	345.64	1556.28	155.86	1.62
3#	55	1385.74	344.88	1554.37	166.76	1.36
4#	136	1389.02	329. 72	1562.83	128.64	2.44
5#	195	1391.87	322.96	1567.35	121.21	2.63
6#	234	1391.56	328.08	1581.28	102.93	3.09

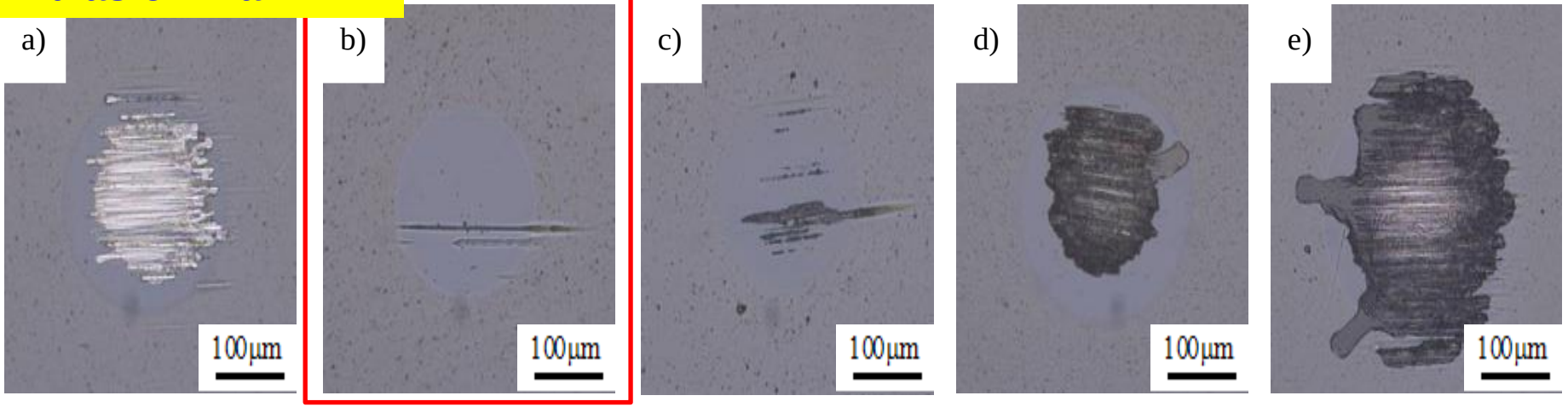
C_2H_2 flows 55sccm, I_d/I_g has the lowest value, the coating shows the highest mechanical strength.

Effect of C_2H_2 content

Vickers hardness crater



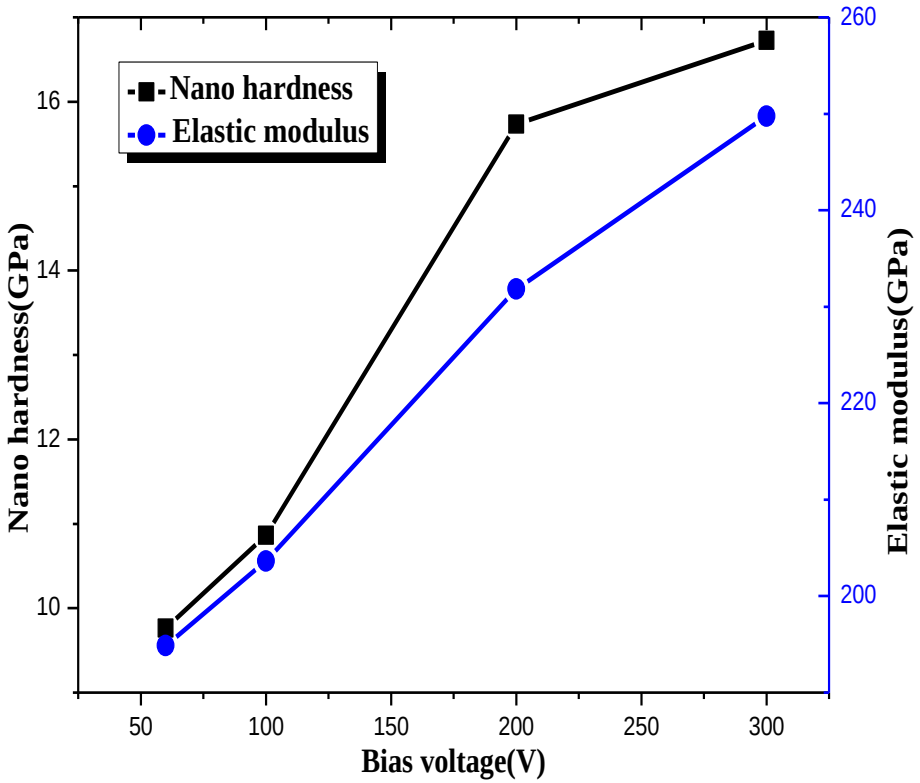
Abrasion mark

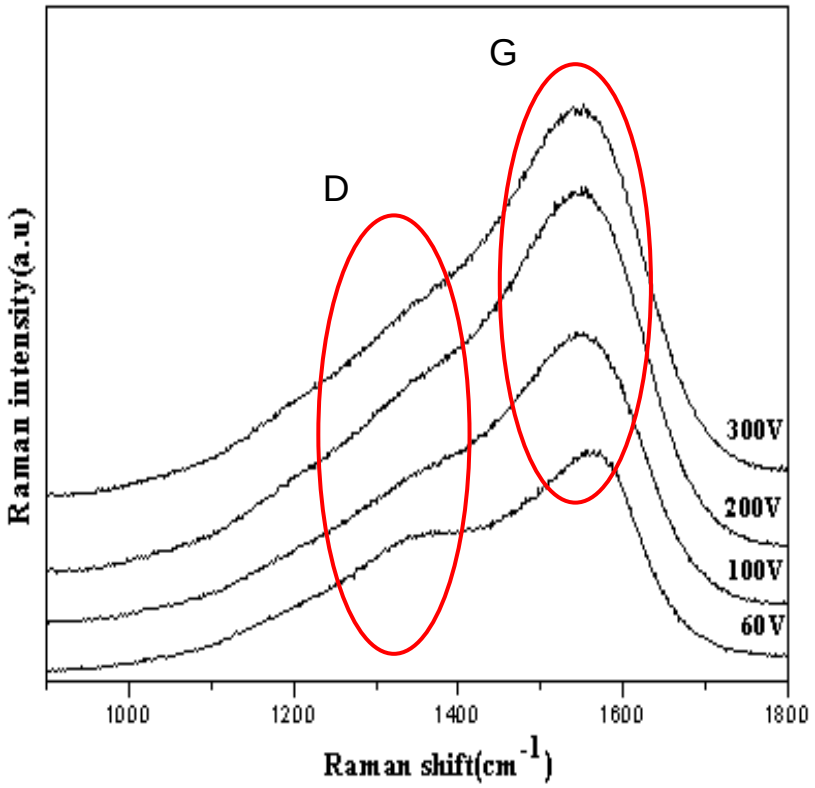


a)C_2H_2=30 sccm; b)C_2H_2=55 sccm; c)C_2H_2=136 sccm; d)C_2H_2=195 sccm; e)C_2H_2=234 sccm

Best overall mechanical properties at C_2H_2 flow of 55 sccm.

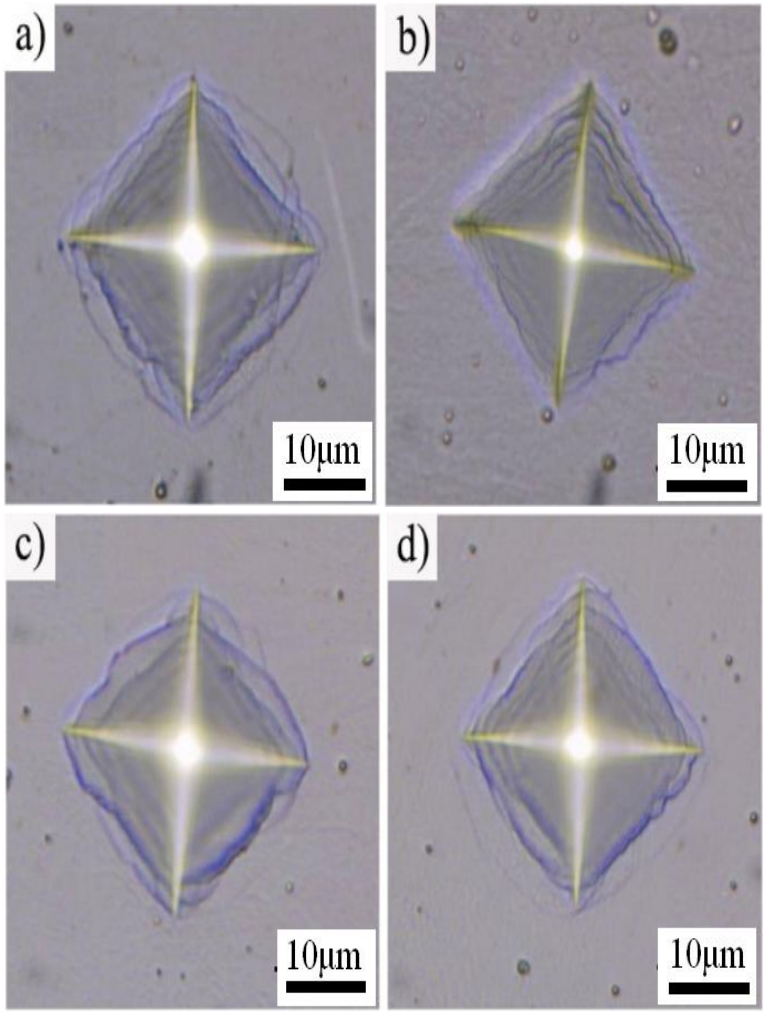
Effect of Bias (60V; 100V; 200V; 300V)



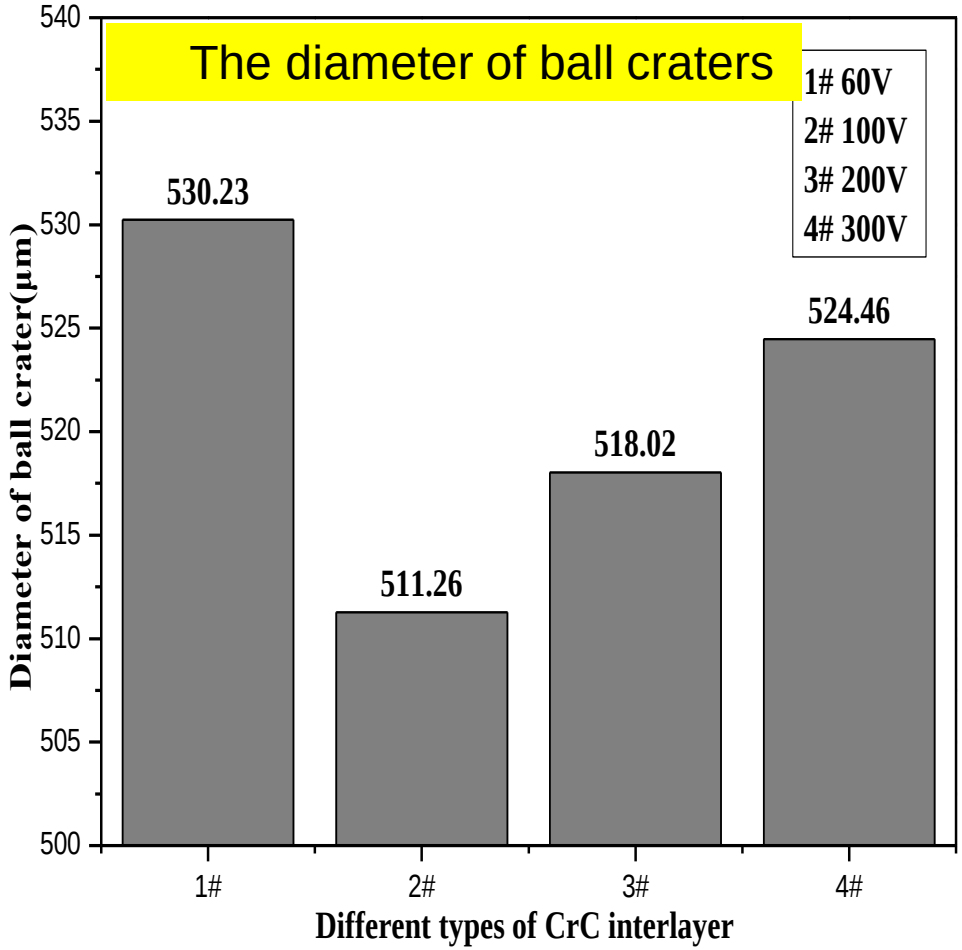


Hardness increases with bias;
I_d/I_g drops with higher bias, which suggests higher bonding strength.

Effect of Bias (60V; 100V; 200V; 300V)

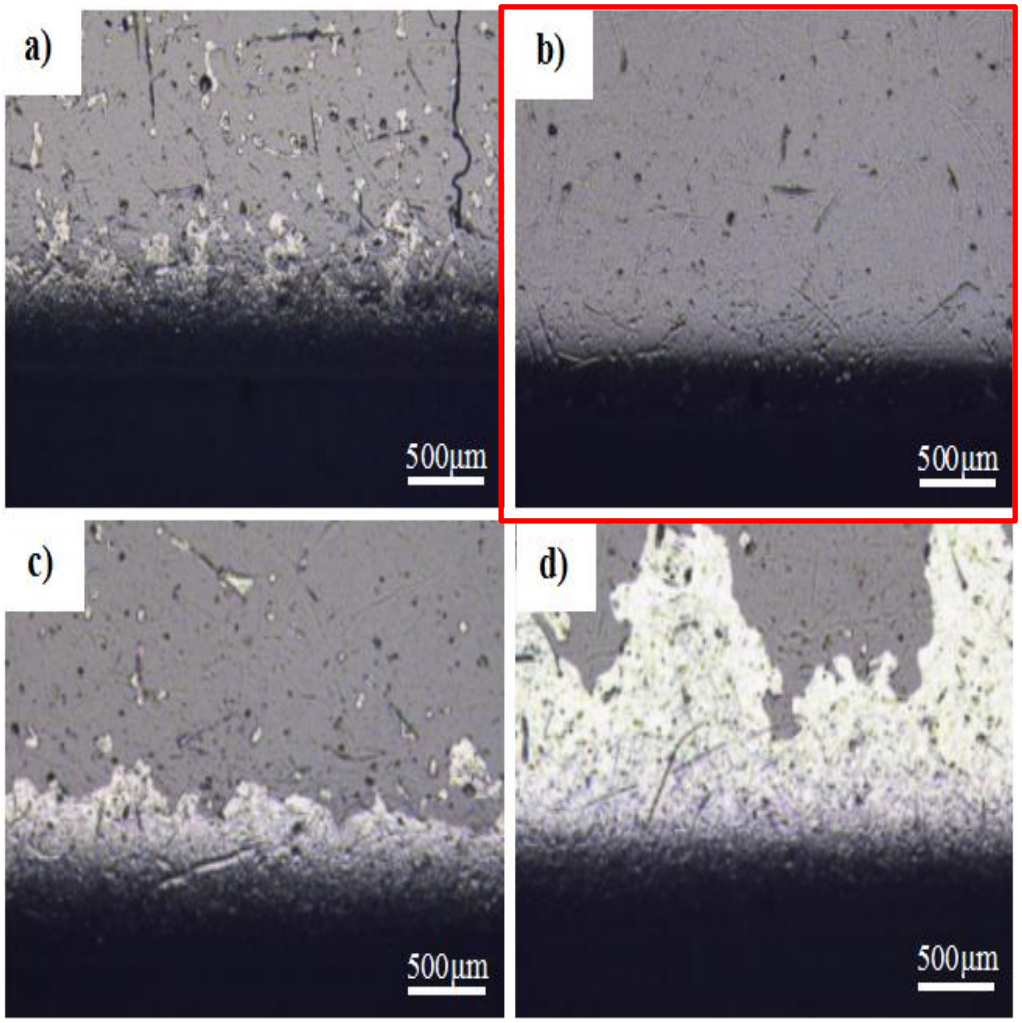


a) 60V; b) 100V; c) 200V; d) 300V



The higher the bias, the lower the ductility.
100V bias shows the excellent overall properties

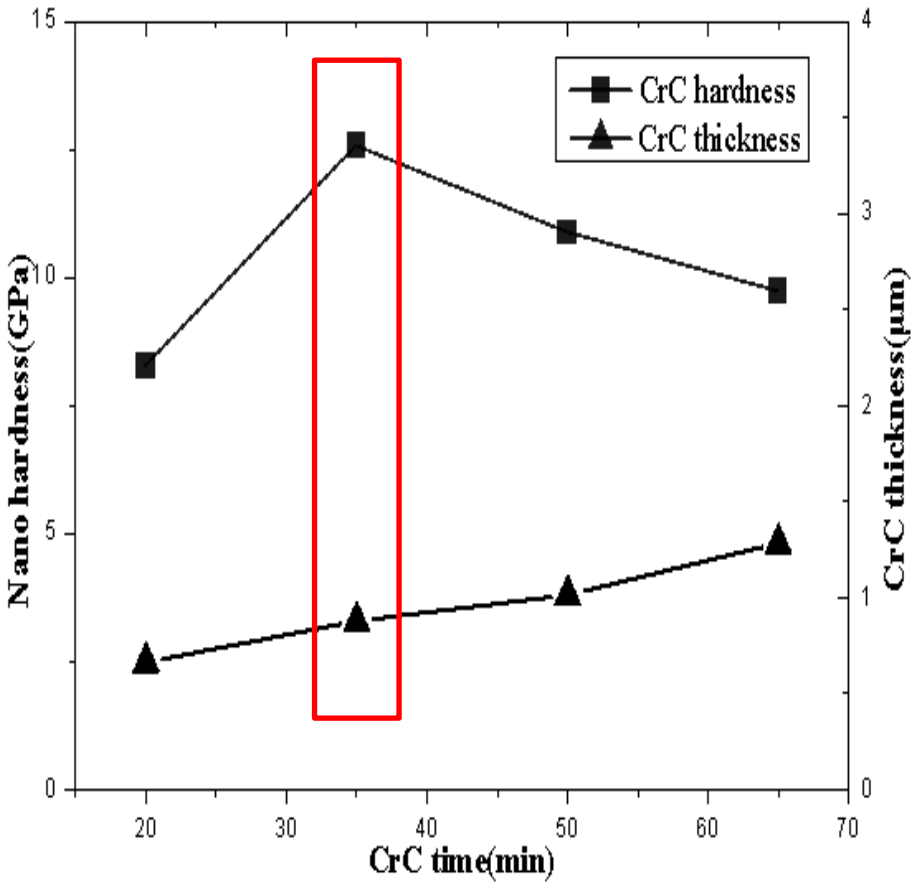
Effect of Bias (60V; 100V; 200V; 300V)



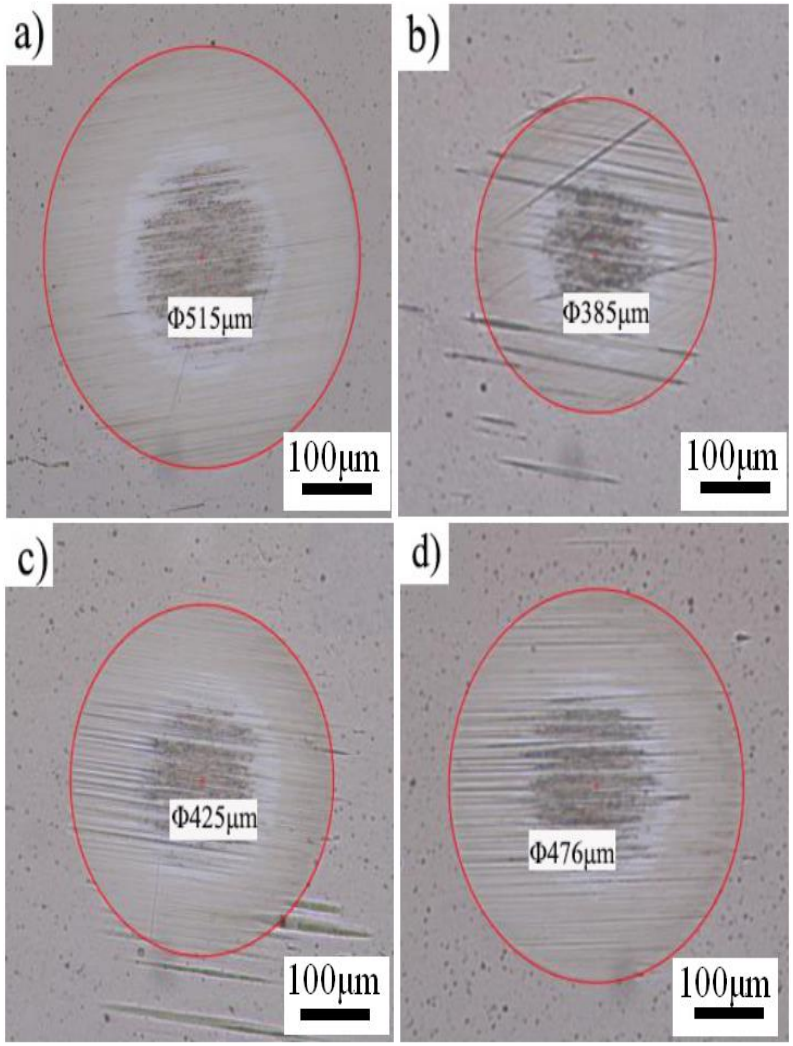
a)60 V ; b)100 V ; c)200 V ; d)300 V

100V bias shows the best vibration abrasion test results

Effect of CrC thickness

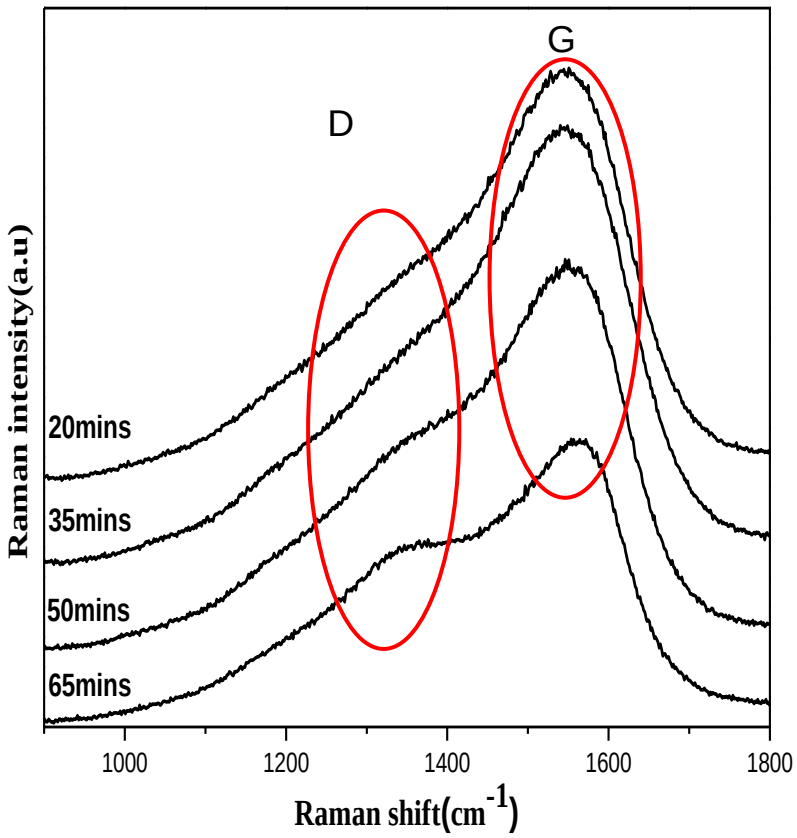


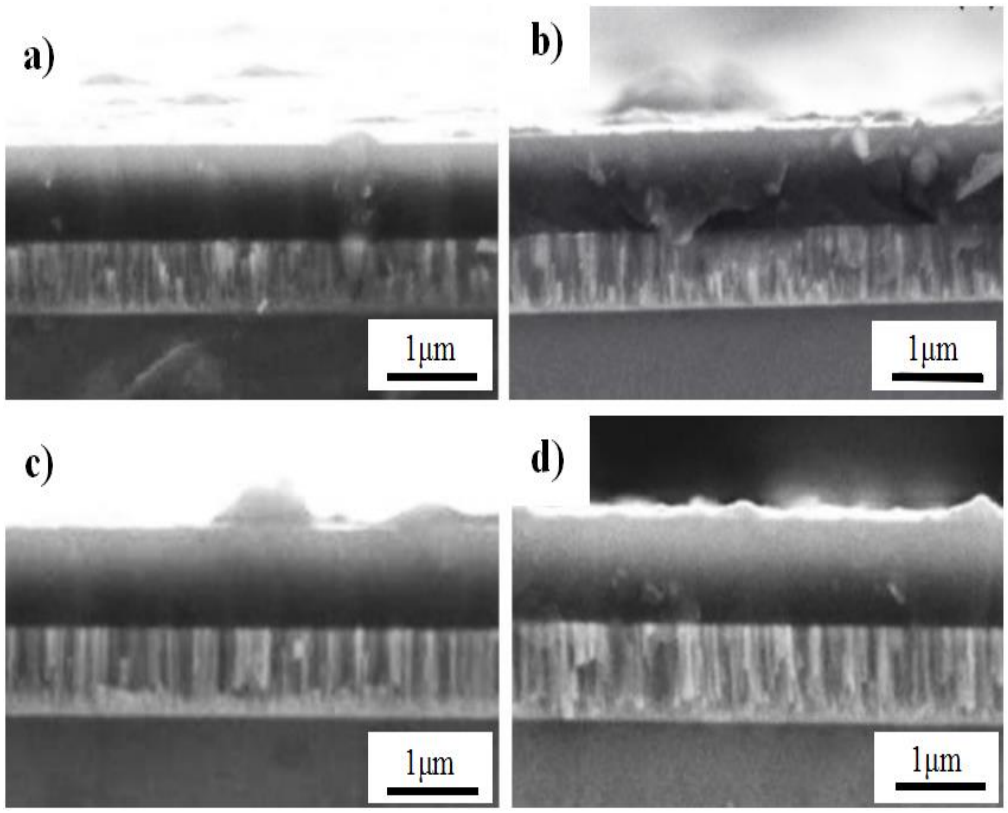
Thickness of 0.815μm CrC coating shows the highest hardness and best abrasion resistance.



a) 0.622 μm; b) 0.815 μm; c) 1.012 μm; d) 1.232 μm

Effect of CrC thickness

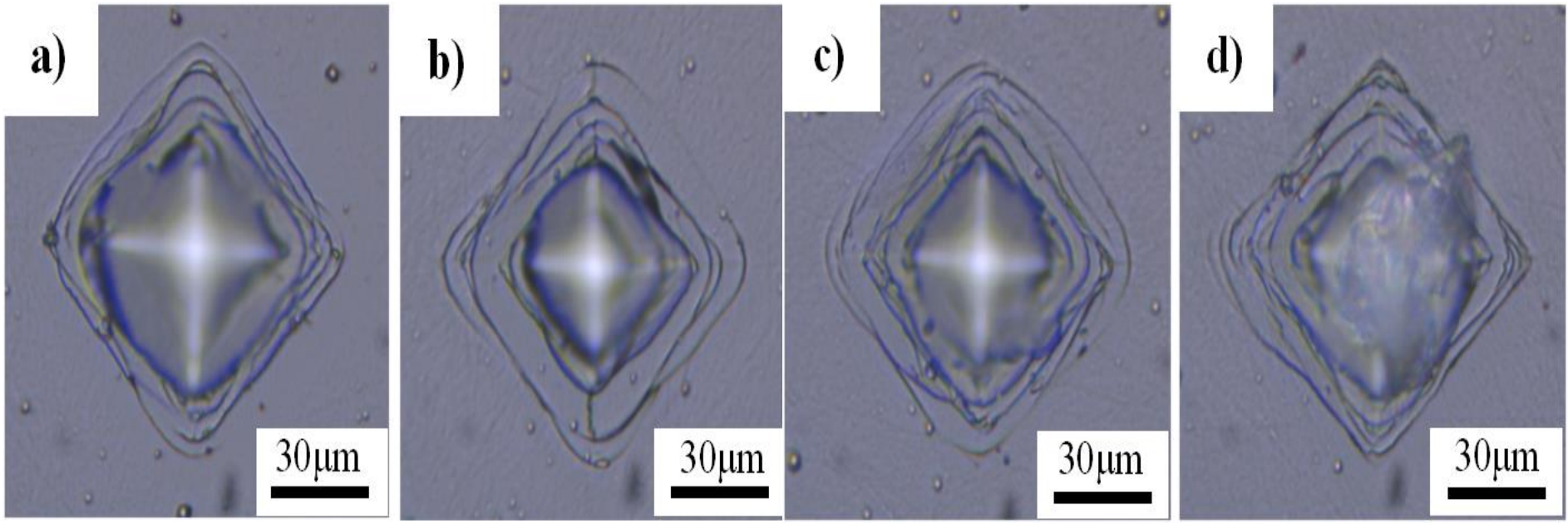




a) 0.622 μm; b) 0.815 μm; c) 1.012 μm; d) 1.232 μm

I_d/I_g drops with thickness, suggesting lower strength;
The thicker the coatings, the less dense it is.

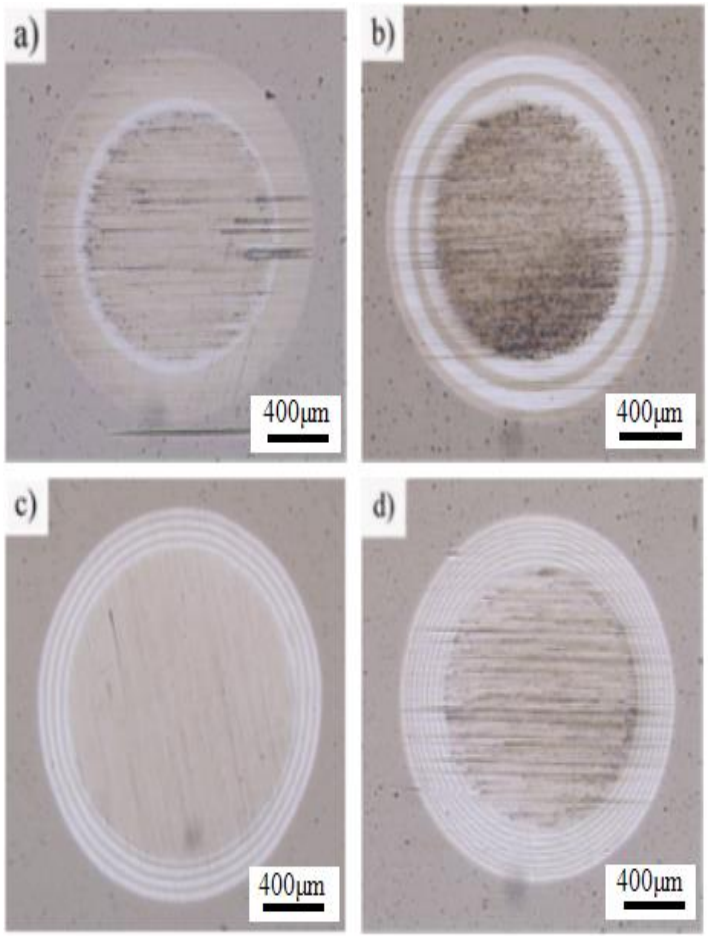
Effect of CrC thickness



a） 0.622 μm; b） 0.815 μm； c） 1.012 μm； d） 1.232 μm

The coating with 0.815μm CrC transition layers shows the excellent overall mechanical properties (Adhesion and elasticity)

Effect of $(Cr/CrC)_x$ superlattice

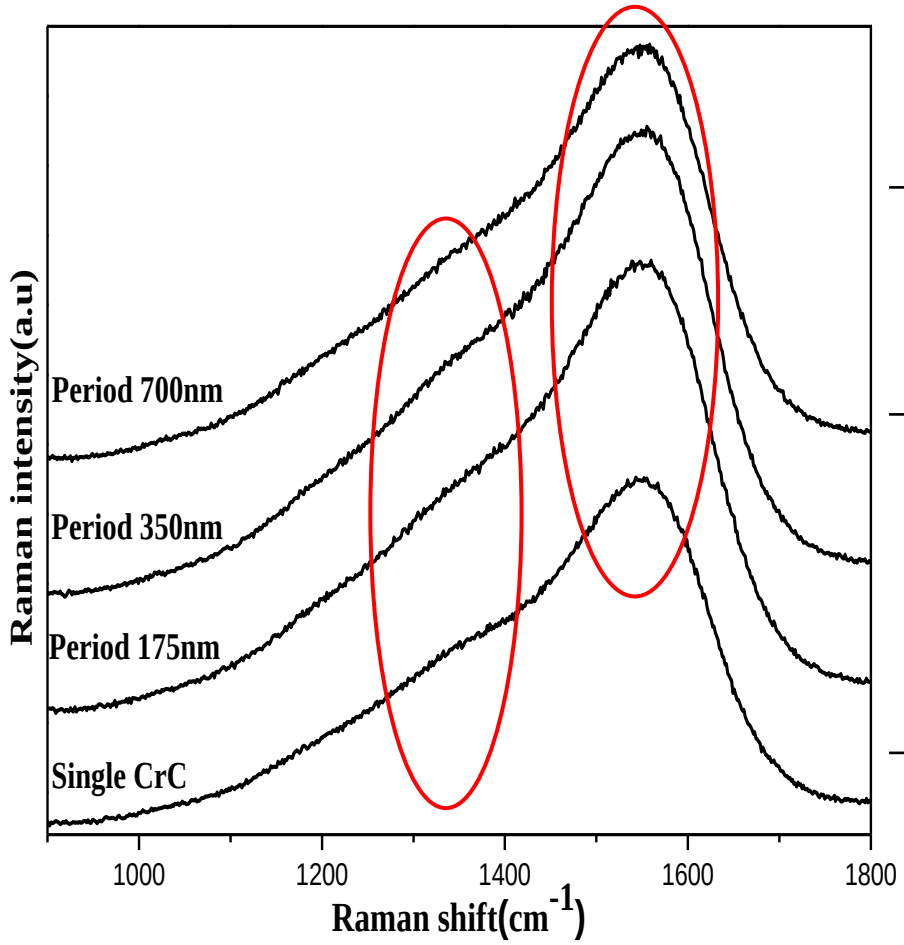


a) Single CrC; b) Modulation 700 nm;
c) Modulation 350 nm; d) Modulatin 175 nm

No.	Modulation	Cr/CrC duration	C_2H_2 in CrC	Bias	Cr Target
1#	700 nm	900 s/900 s	55 sccm	100 V	30 A
2#	350 nm	450 s/450 s	55 sccm	100 V	30 A
3#	175 nm	225 s/225 s	55 sccm	100 V	30 A

No.	Modulation	Nano hardness/Gpa	Hardness/HV
1#	Cr	8.858	114.9
2#	CrC	10.374	137.6
3#	Modulation 700nm	9.022	125.5
4#	350nm	12.531	144.5
5#	175nm	13.678	152.7

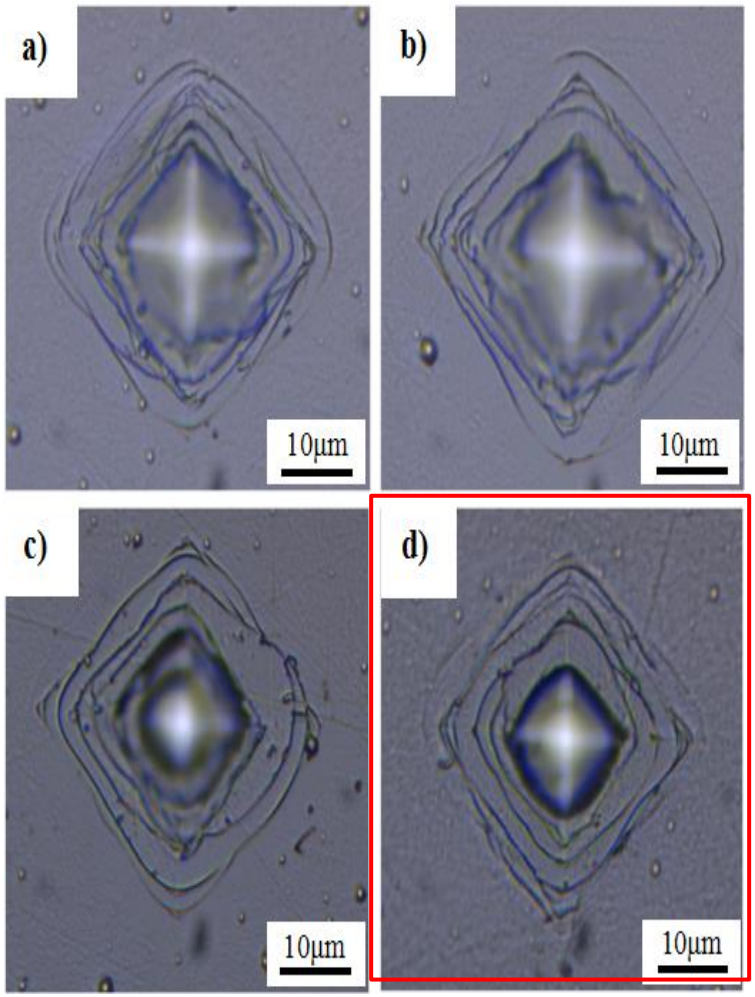
Effect of $(Cr/CrC)_x$ superlattice

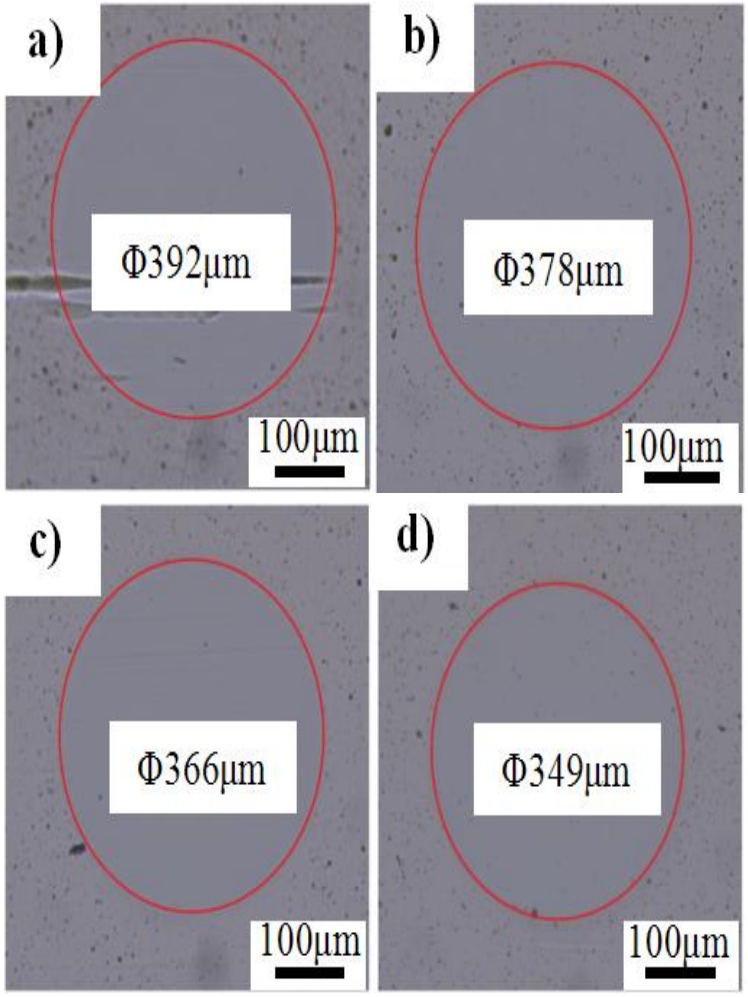


No.	Modulation/nm	D		G		I_d/I_g
		Peak/cm^{-1}	FWHM/cm^{-1}	Peak/cm^{-1}	FWHM/cm^{-1}	
1#	CrC	1390.04	345.64	1558.28	155.86	1.62
2#	700nm	1389.29	344.31	1557.64	158.25	1.59
3#	350nm	1390.06	346.51	1557.12	159.65	1.52
4#	175nm	1388.26	348.06	1556.02	161.08	1.50

I_d/I_g Drops with narrower modulation, suggesting higher adhesion

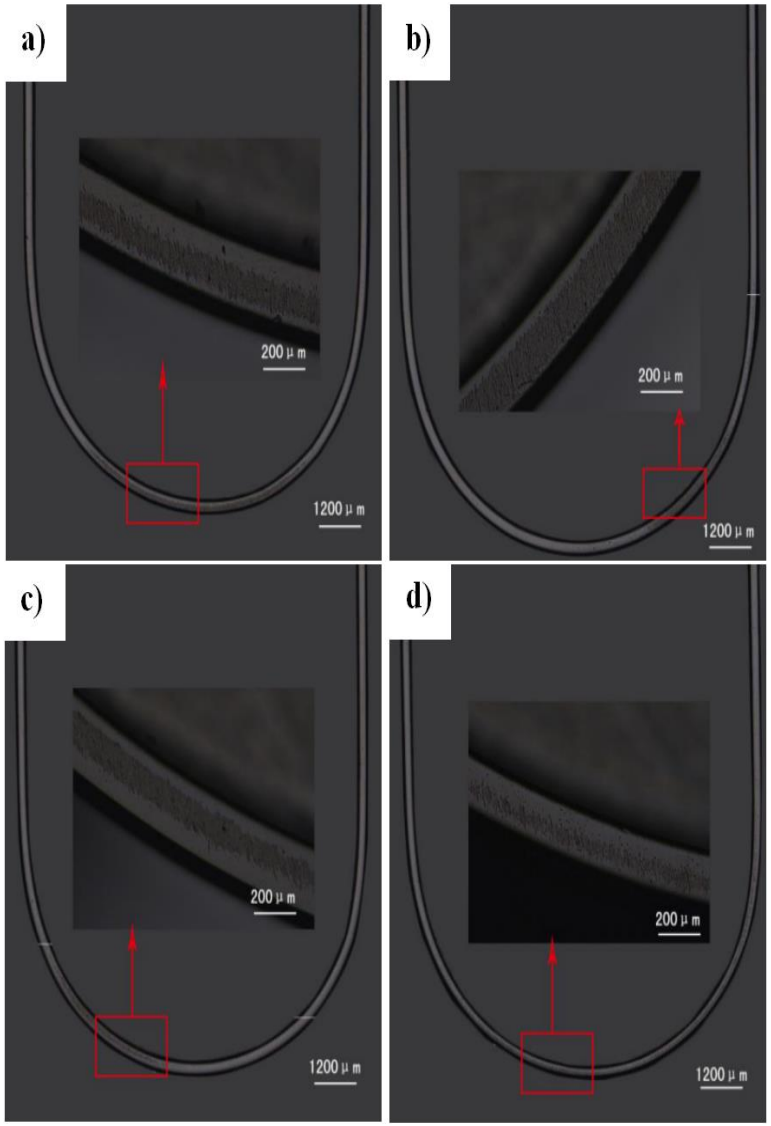
Effect of $(Cr/CrC)_x$ superlattice





a) Single CrC; b) Modulation 700 nm; c) Modulation 350 nm; d) Modulatin 175 nm

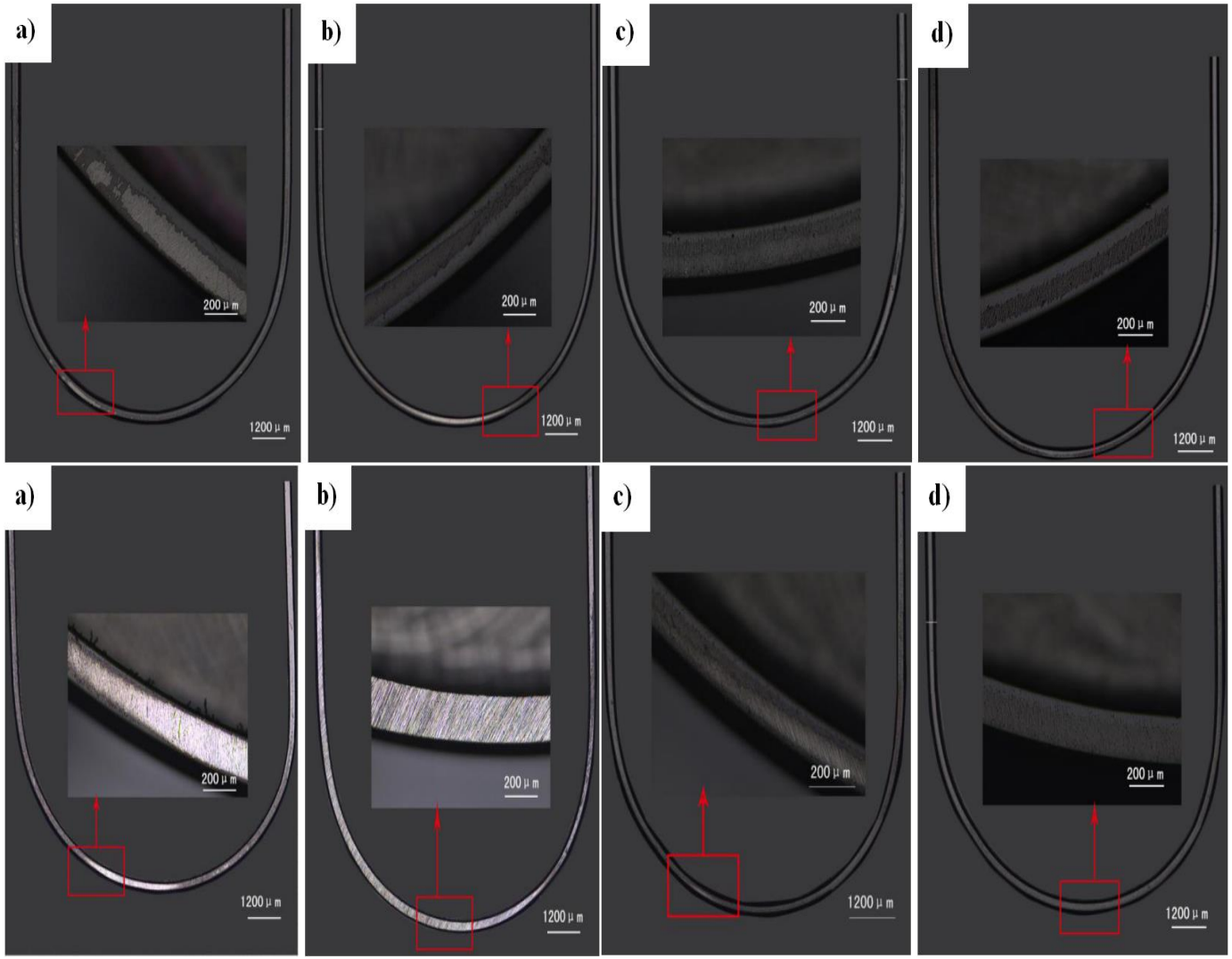
Reliability test on real parts



Reliability test on real parts

2000#
sand paper

1000#
sand paper



Summary

- Based on the properties, the optimized CrC parameters:
  - As the Cr:C ratio reaches 1:1, the coatings shows the optimized properties
  - The CrC with the thickness of 0.815μm shows the highest hardness of 12.4 Gpa.
  - 100V of bias shows the optimized properties;
- As the modulation of (Cr/CrC)x superlattice decreases, the hardness, bearing capacity and abrasion resistance increases, therefore **the multilayers with the smallest modulation is the best PVD supporting layer for DLC coatings**.

Decorative Coatings

森科 五金
TRITREE METAL

Gun，
Titanium
Gray, Black

Blue, Brown, Coffee, Purple

Gold

Black

Rose Gold

Colorful

Imation Gold

Customized color

IP Gold

Rose Gold

Lower cost, Durable

Thank You!

Tritree Metal (Shenzhen) Co., Ltd

Address: Building 1, Shiguan Industrial Park, New Guangming District, Shenzhen, Guangdong, China 518106

Tel: +(86)755-27156208 27156698

Fax:+(86)755-27156899

E-mail: amanda@tritree.cn

Web: http://www.tritree.cn