HYBRID THERMALLY SPRAYED COATINGS DEPOSITION USING GRAPHENE FAMILY NANOMATERIALS AS LUBRICATION FACILITATORS FOR WEAR RESISTANT APPLICATIONS

EBETAM MIRTEC

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Introduction

Metal Matrix Composite materials have been widely used since many years in every day industrial practice as coatings to provide higher mechanical strength, elastic modulus, yield strength, wear and abrasion resistance compared to monolithic metal components. Thermal spray is for many decades a well-established technology for the deposition of these coatings. Lately Graphene Family materials such as carbon nanotubes (CNTs), graphene oxide etc. are potential candidates as reinforcement particulates in metal matrix composites due to their exceptional mechanical, electrical and thermal properties with additional interest in their micron to nano scale size.

In the current study it is presented:

- **The addition procedure of CNTs in metal and cermet powders for the development of homogenized mixtures to be used as feedstock materials during Atmospheric Plasma Spraying (APS) deposition.**
- **The reference coatings (metallic powders) properties and characteristics compared to hybrid ones (respective feedstock powders with CNTs addition).**
- **Tribological and other properties measurements and characterizations (wear resistance, friction coefficient, microhardness)**

Motivation

- **Feedstock powders: Commercial suitable for thermal spray and respective optimized mixtures with CNTs.**
- **Optimization of the Atmospheric Plasma Spray (APS) conditions for the deposited coatings.**
- **Development and characterization (tribological, mechanical & microstructural) of hybrid APS coatings towards applications with intense lubrication requirements.**

Experimental

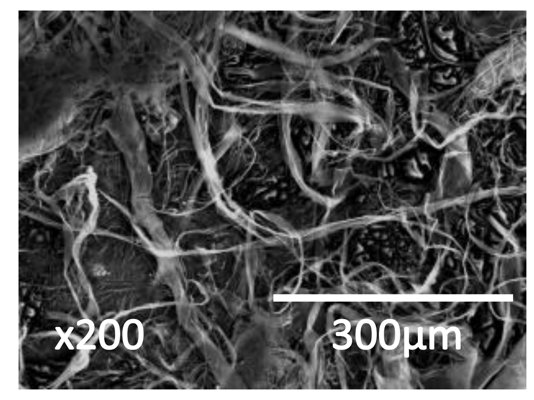
Powder Mixture Composition

Feedstock powders (wt%):

- WC-Co, 83-17
- CoNiCrAlY-CrC-CrB_2-Y_2O_3, 43-25-7-25

CNTs powder:

- Single-walled carbon nanotubes (SWCNTs) 99±0,5%

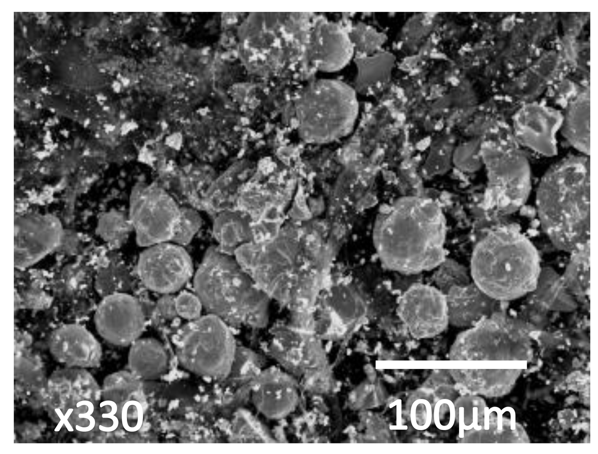


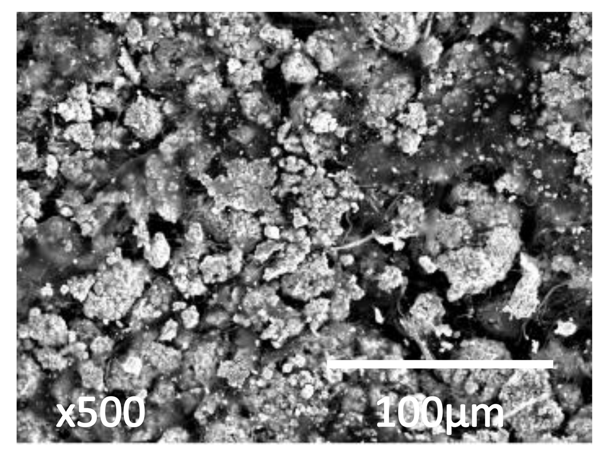
SWCNTs

Powder mixtures homogenization

Metallic powders dry ball milling with 5 wt% SWCNT's for 72h

CoNiCrAlY-CrC-CrB_2-Y_2O_3 powder with SWCNTs





WC-Co powder with SWCNTs

Deposition of hybrid thermal spray coatings

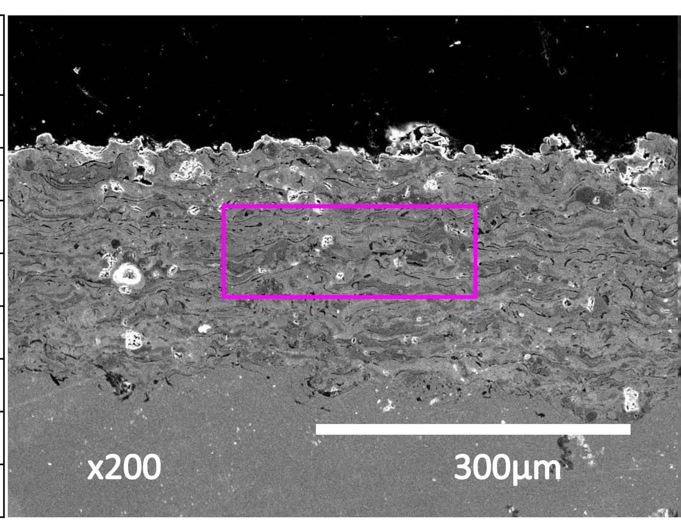
Thermal Spray system: Praxair SG-100 atmospheric plasma spraying gun attached to a 6-axis Motoman robotic arm.

Substrates: SL316 stainless steel (30mm x 30mm x 3mm and 15 mm x 20 mm x 2 mm)

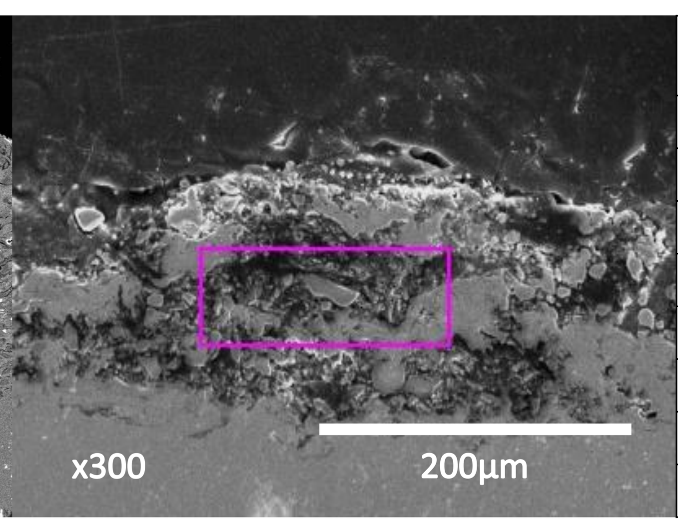
Results and discussion

Microstructural and elemental analysis of reference and hybrid coatings deposited by APS

Element	Weight %
C K	10.15
O K	5.88
Al K	2.97
Cr K	31.23
Co K	12.91
Ni K	12.17
Y L	24.71
Totals	100.00



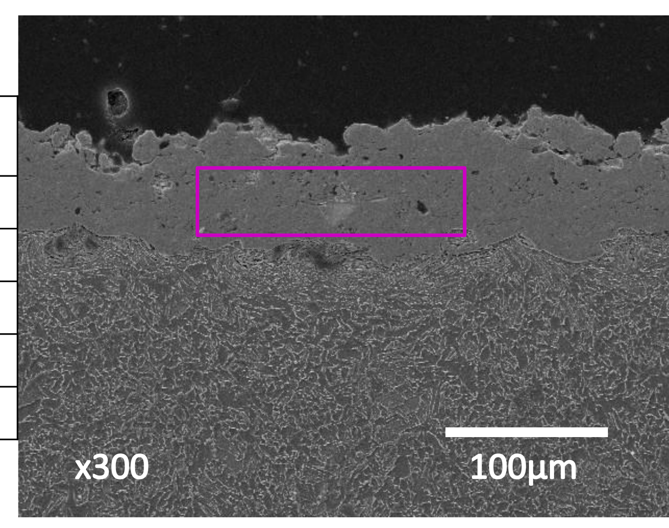
Reference CoNiCrAlY-CrC-CrB_2-Y_2O_3 coating



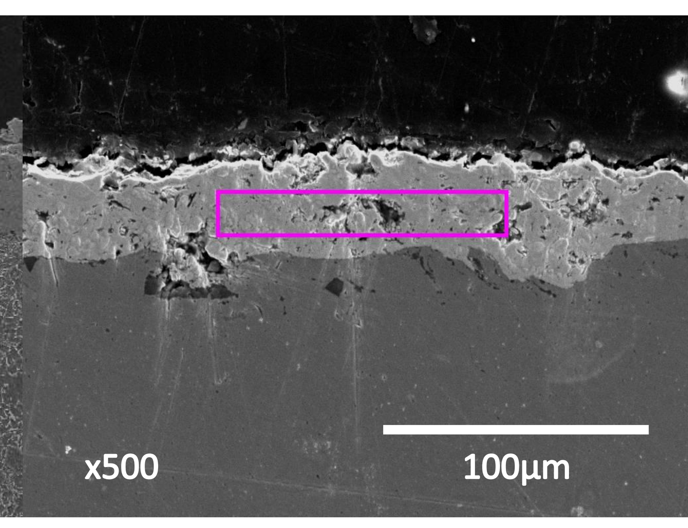
Hybrid CoNiCrAlY-CrC-CrB_2-Y_2O_3 coating

Element	Weight %
C K	48.08
O K	4.47
Al K	2.01
Cr K	16.43
Co K	8.59
Ni K	7.76
Y L	12.66
Totals	100.00

Element	Weight %
C K	3.30
O K	1.44
Co K	16.26
W M	79.00
Totals	100.00



Reference WC-Co coating

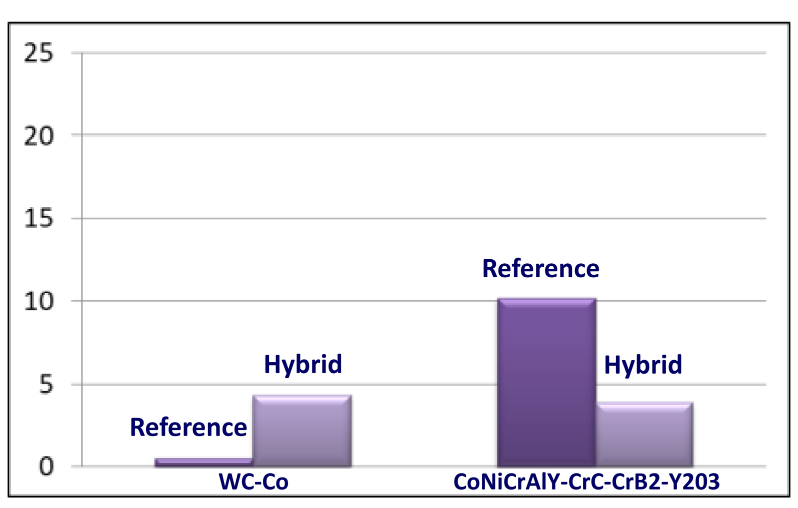


Hybrid WC-Co coating

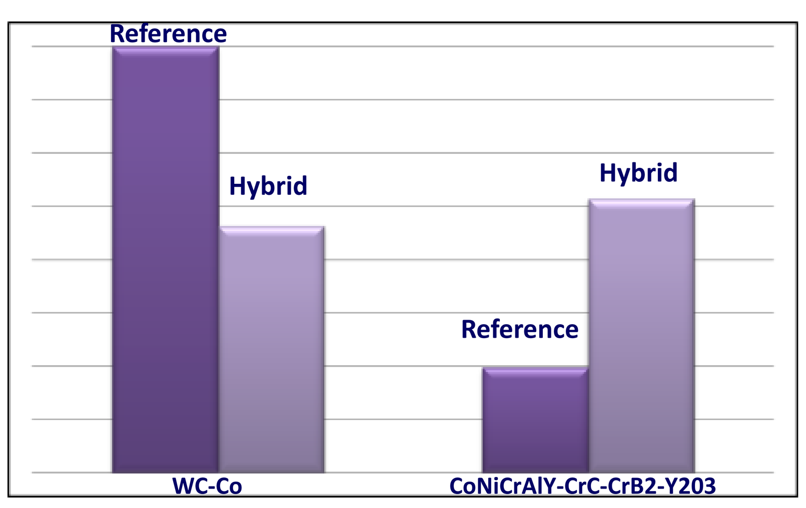
Element	Weight %
C K	8.93
O K	1.98
Al K	17.21
Cr k	71.87
Totals	100.00

- **CNTs addition does not affect significantly the microstructural characteristics of hybrid coatings compared to the reference ones. EDS analysis confirms the C content increase in the hybrid coatings.**

Wear rate & wear resistance against WC ball, 5000 cycles, load 10N

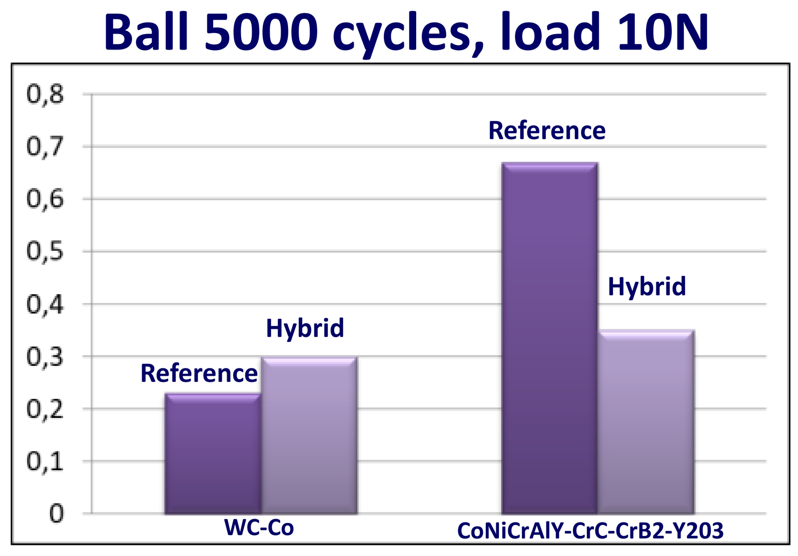


The wear rate value is decreased for the CoNiCrAlY-CrC-CrB_2-Y_2O_3 coating and slightly increased for the WC-Co with 5 wt% CNTs addition.



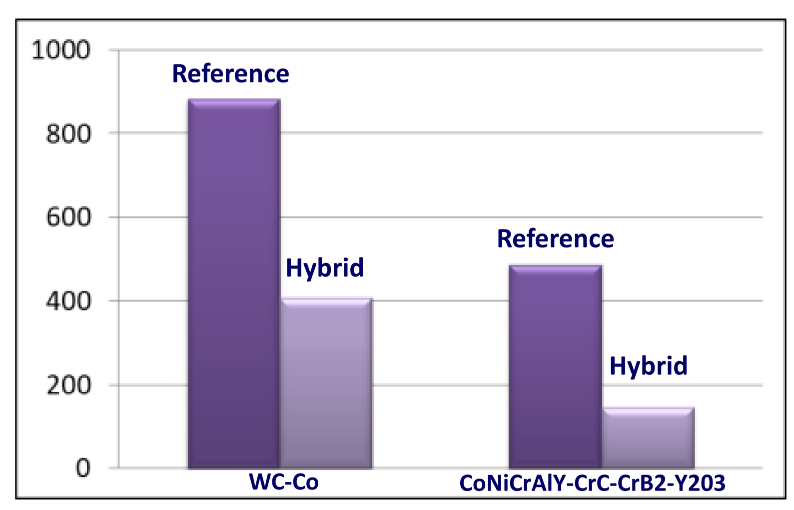
These qualitative results show that CNTs significantly increase the wear resistance of the CoNiCrAlY-CrC-CrB_2-Y_2O_3 coating (by 2,5 times). The opposite behavior is observed for the WC-Co coating.

Friction coefficient against WC Ball 5000 cycles, load 10N



CNTs' reinforcement decreases the coefficient of friction for the CoNiCrAlY-CrC-CrB_2-Y_2O_3 coating.

Vickers Microhardness



The addition of CNTs has similar effect in microhardness measurements for both coatings, reducing their values.

Conclusions

- **Successful incorporation of CNTs homogeneously dispersed within the hybrid coating mass has been performed as shown by SEM/EDS analysis.**
- **As expected, the hybrid coatings Vickers microhardness is decreased compared to the reference coatings.**
- **Coating reinforcement with CNTs results in substantial improvement of the anti-wear behavior of CoNiCrAlY-CrC-CrB2-Y203 coating result which is also supported by its friction coefficient decrease.**

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HYSELFDROPS

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