Karlsruhe Institute of Technology

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PLANSEE

Large Scale Deposition of TiC/a-C Nanocomposite Coatings by Magnetron Sputtering using Novel Ceramic Compound Targets

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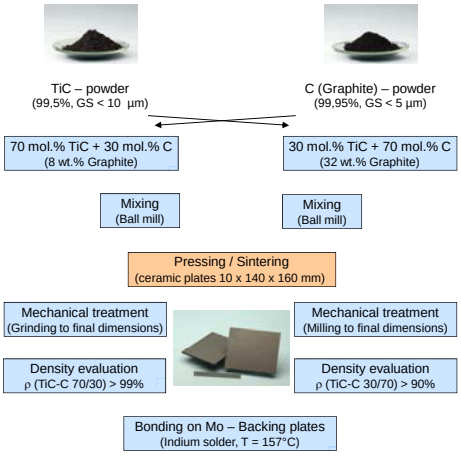
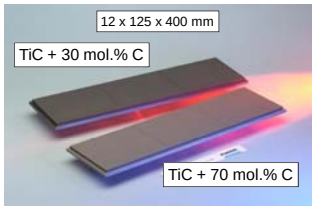
Motivation & Approach

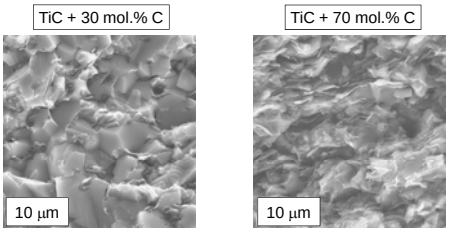
Carbon-based nanostructured composite thin film materials such as **TiC/a-C** have attracted large scientific and technical attention with regard of their interesting properties, addressing not only tribological applications (by high wear resistance and simultaneously low friction coefficients) but also electrical, optical and many other applications. In the past few years the knowledge on the **correlation between synthesis conditions, growth, microstructure and properties** of these kind of materials has enormously increased. However, industrial applications have so far mainly been established for WC/a-C coatings in tool applications. This situation is partially related to the **lack of appropriate processes for large scale deposition** of such materials over a wide range of coating compositions and on complex shaped component geometry. In this work the large scale deposition of TiC/a-C nanocomposite coatings by means of non-reactive D.C. magnetron sputtering is reported. A **novel process route on production level using innovative, newly developed hot-pressed ceramic compound targets of individual TiC:C compositions** is presented.

Target Manufacture

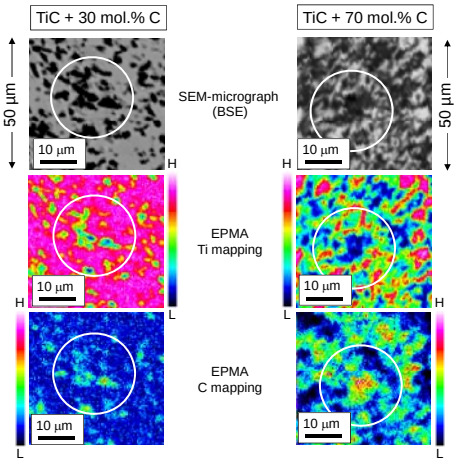


Target Characterization (I)



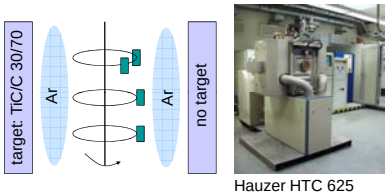


Target Characterization (II)



Thin Film Deposition (I)

Non-reactive D.C. magnetron sputtering of TiC/C 30/70 target



Hauzer HTC 625

process parameters		substrate temperature		
		< 100 °C	100 °C	200 °C
coil current	0 A	X	X	X
	3 A	X	X	X
	5 A	X	X	X

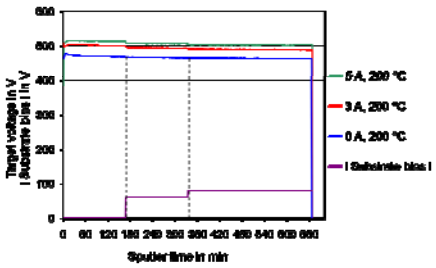
gas pressure: 0.28 Pa Ar

target power: 4 W/cm² (2 kW)

substrate bias gradient: 0 V/ -60 V/ - 80 V

Thin Film Deposition (II)

TiC/C 30/70 target: operation characteristics



- 2 targets of identical composition (TiC/C 30/70)
- 2-fold sample rotation
- growth rate ~ 0.3 µm/h
- coating thickness 3 – 4 µm
- substrates: cemented carbide, Si wafer

TiC/a-C Nanocomposite Films (I)

Electron Probe Micro Analysis (EPMA)

Target no. 1 (TiC/C 30/70), substrate temperature < 100 °C

	analyzed elements in at.%					[Ti]/[C]
sample	[Ti]	[C]	[Ar]	[N]	[O]	
0 A	19.7	73.2	3.0	2.4	1.7	0.27
3 A	21.6	72.3	3.2	2.7	0.3	0.30
5 A	20.2	72.5	3.5	3.1	0.7	0.28

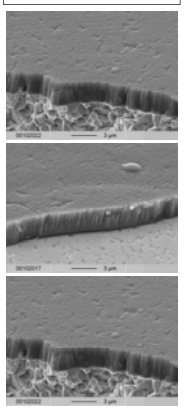
Target no. 2 (TiC/C 30/70), substrate temperature < 100 °C

	analyzed elements in at.%					[Ti]/[C]
sample	[Ti]	[C]	[Ar]	[N]	[O]	
0 A	20.5	72.1	3.2	2.9	1.3	0.29
3 A	22.0	72.5	3.1	2.1	0.3	0.30
5 A	22.1	71.2	3.4	2.7	0.5	0.31

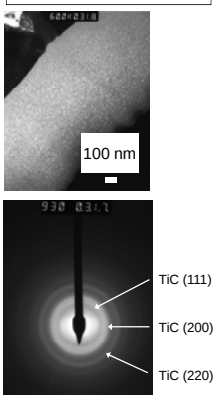
target composition: 23.1 at.% Ti, 76.9 at.% C - [Ti]/[C] = 0.3

TiC/a-C Nanocomposite Films (II)

SEM images
(target no. 1, < 100 °C)



TEM analysis (DF, SAED)
(target no. 1, < 100 °C, 5 A)



Conclusions

We have successfully demonstrated the **large scale deposition of TiC/a-C nanocomposite coatings** by means of non-reactive D.C. magnetron sputtering.

Novel ceramic TiC/C compound targets of various composition were successfully used for PVD deposition.

Reliebale and **reproducible deposition processes** on pre-industrial level have been demonstrated.

The **coating of complex 3D-shaped geometries** at low substrate temperature was successfully demonstrated.

Use of ceramic compound targets for arc evaporation ?

TiC/a-C coated drilling tool (with thin TiN topcoat)

Acknowledgement

We appreciate the target supply and cooperation with Plansee Composite Materials GmbH, and especially with Dr. Arno Schintlmeister, Technical University of Vienna.