Mechanical and tribological characterization of CN_x films deposited by d.c. magnetron sputtering

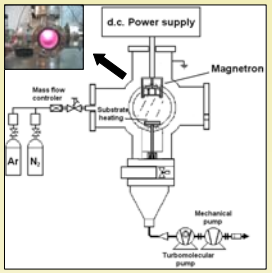
L. Ipaz[1], L. Yate [1], T. Polcar [3], E. Camps[4], L. Escobar-Alarcon[4], G. Zambrano[1], P. Prieto[1]

[1] *Thin Films Group, Department of Physics, Excellence Center for Novel Materials, Universidad del Valle, Cali, Colombia*
[3] *Department of Applied Mathematics, Faculty of Transportation Sciences, CTU in Prague, Czech Republic*
[4] *Department of Physics, Instituto Nacional de Investigaciones Nucleares, México*

Goals

- Growth and mechanical - tribological characterization of CN_x thin films deposited by d.c. magnetron sputtering onto silicon and AISI D3 steel.

Experimental

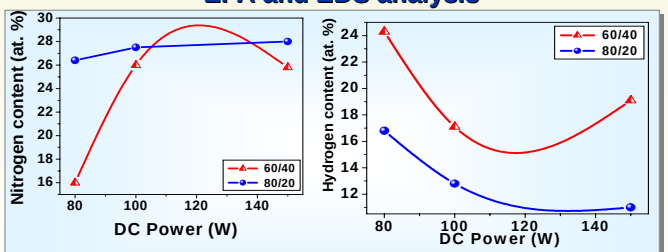


Deposition parameters of CN_x thin films

Target	Graphite (99.99%, 1 inch diameter)
Deposition technique	Reactive magnetron sputtering d.c.
Target power (W)	80, 100, 150
Distance target - substrate (cm)	4.5
Nitrogen content in (Ar/N_2) gas mixture	60/40, 80/20, 90/10
Work pressure (N_2+Ar) (mbar)	$5x10^{-2}$
Substrates	Silicon and AISI D3 steel
Substrate temperature (°C)	400

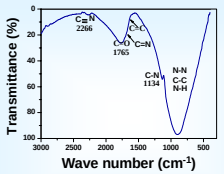
Results

EFA and EDS analysis



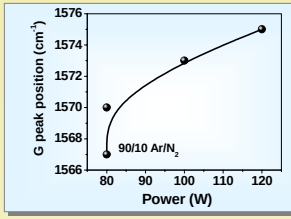
Nitrogen and Hydrogen content of films deposited at different applied powers, determined from EFA analysis.

FTIR analysis



FTIR spectrum of CNx film, deposited at 150 W, 400 ° C, and (60/40) of the Ar/N_2 gas mixture.

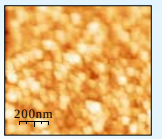
RAMAN analysis



Position of G peak, as a function of the working power, for a fixed working 60/40 Ar/N_2 gas mixture

AFM analysis

Ar/N_2	Power (W)	Roughness (nm)	Grain Size (nm)
60/40	100	2.62	105
80/20	100	5.70	140
80/20	150	3.35	35



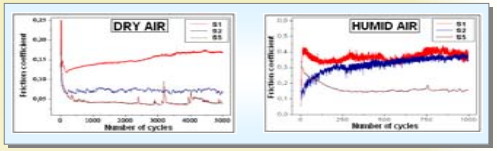
Typical AFM image of film deposited at 80 W and 60/40 Ar/N_2 gas mixture .

Mechanical and tribological results

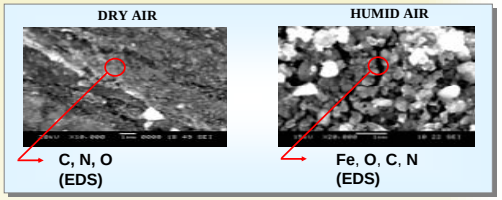
Sample	Ar/N_2	Power (W)	N (at.%)	H (GPa)	E (GPa)	Friction Coefficient		Wear rate ($10^{-6}mm^3/Nm$)	
						DA	HA	DA	HA
S1	60/40	80	16.0	4.2 ± 0.4	68 ± 3	0.160	0.39	0.11	26
S2	60/40	100	26.0	3.2 ± 0.4	76 ± 7	0.072	0.33	0.08	17
S3	60/40	150	25.8	3.0 ± 0.2	43 ± 1	0.091	0.31*	0.08	Failure
S4	80/20	80	26.4	3.3 ± 0.6	48 ± 10	0.200	0.30	0.23	30
S5	80/20	100	27.5	2.1 ± 0.1	35 ± 1	0.045	0.18	-	-
S6	80/20	150	28.0	1.8 ± 0.1	30 ± 1	0.052	0.17*	-	Failure
S7	90/10	80	12.0	17.0 ± 0.1	170 ± 1	-	-	-	-

* Average value of friction coefficient up to failure

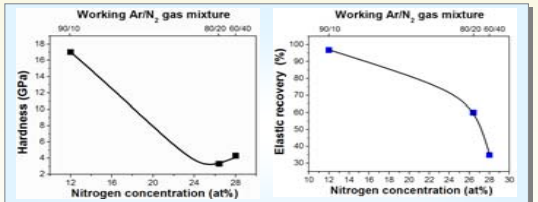
Friction Coefficient



Friction coefficient versus number of sliding cycles.



SEM of wear debris particles taken from the S2 coating wear track after the sliding test.



Nitrogen content influence in the hardness and elastic recovery of the films

Conclusions

Based on our studies of the friction coefficient and wear behavior of the CN_x coatings deposited onto pieces of silicon wafers and steel substrates by magnetron sputtering, analysis of chemical composition, structure and morphology, and analysis of the wear tracks and wear debris using SEM/EDS, we draw following conclusions:

- The deposited CNx coatings can be characterized as a-C:N
- The hardness decreases with increasing the nitrogen content in the films.
- The friction coefficient is lower for sliding in dry air
- The wear rates of the coatings tested at humid air are about two orders of magnitude higher compared to the wear rates at dry air.

Acknowledgements

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