UNIVERSITÀ
DEGLI STUDI
DI PADOVA

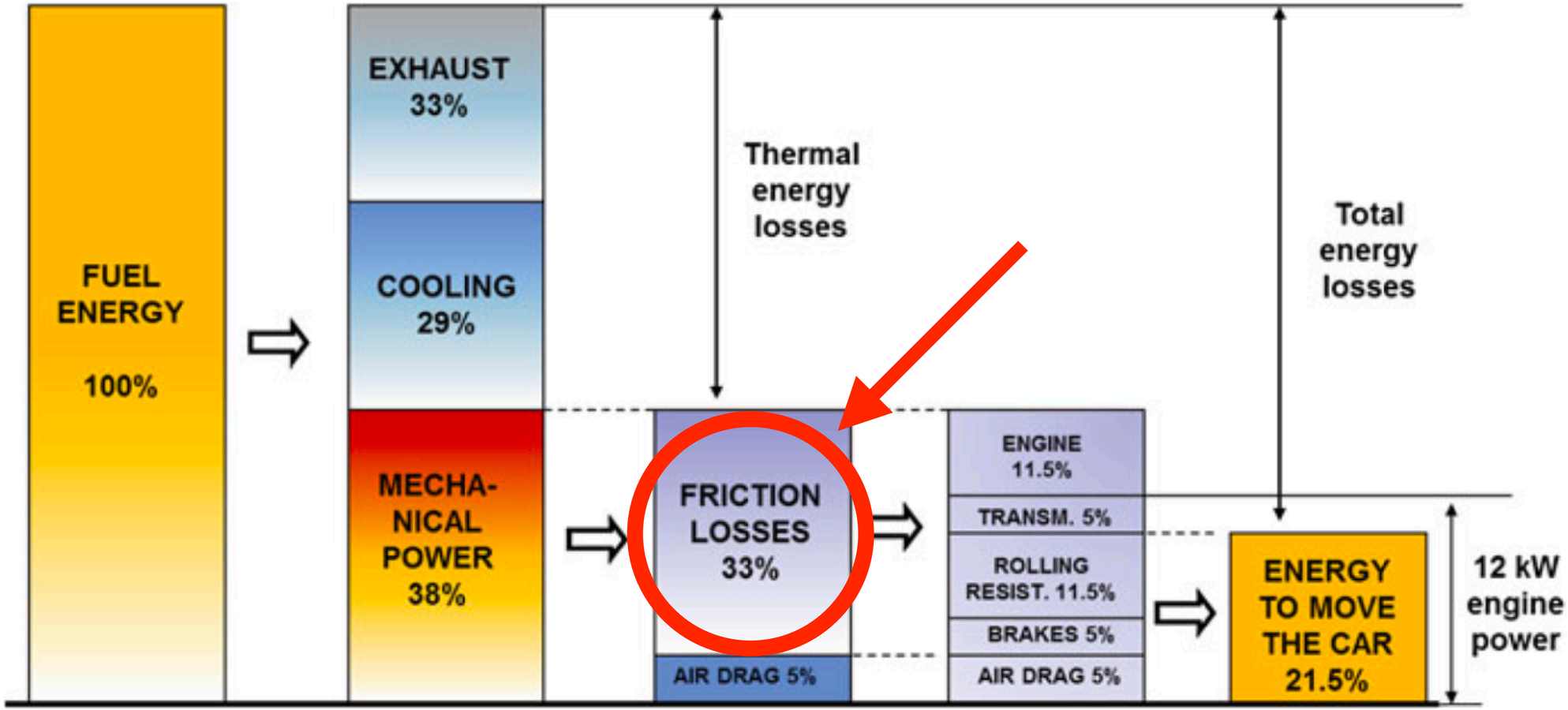
Dipartimento di Scienze Chimiche

Corso di Laurea in Scienza dei Materiali

Film sottili di DLC depositati attraverso tecniche PVD per applicazioni in ambito automotive

Davide Saltarello - Matricola 1239019
Padova, 18 luglio 2024

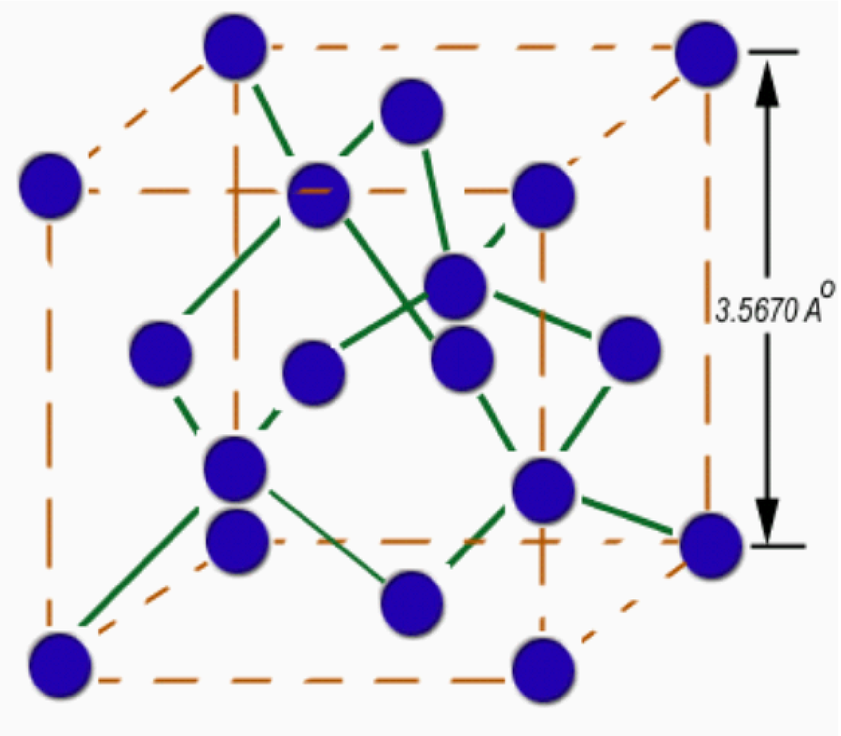
FRICTION AND ENERGY LOSS



DIAMOND LIKE-CARBON (DLC)

Solid lubricant
Amorphous
Excellent tribological properties

DIAMOND LIKE-CARBON (DLC)



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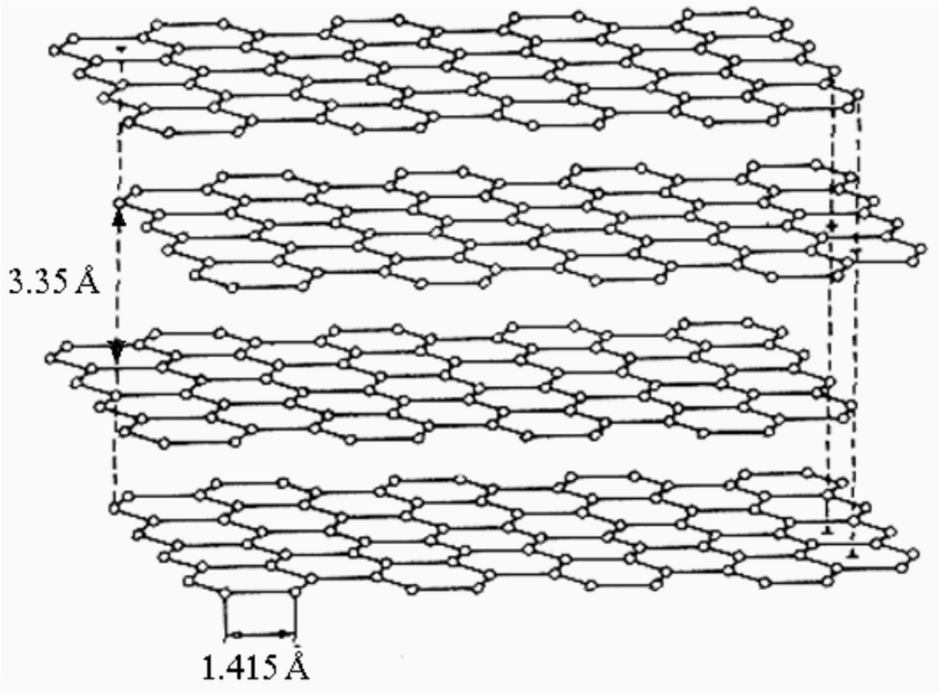


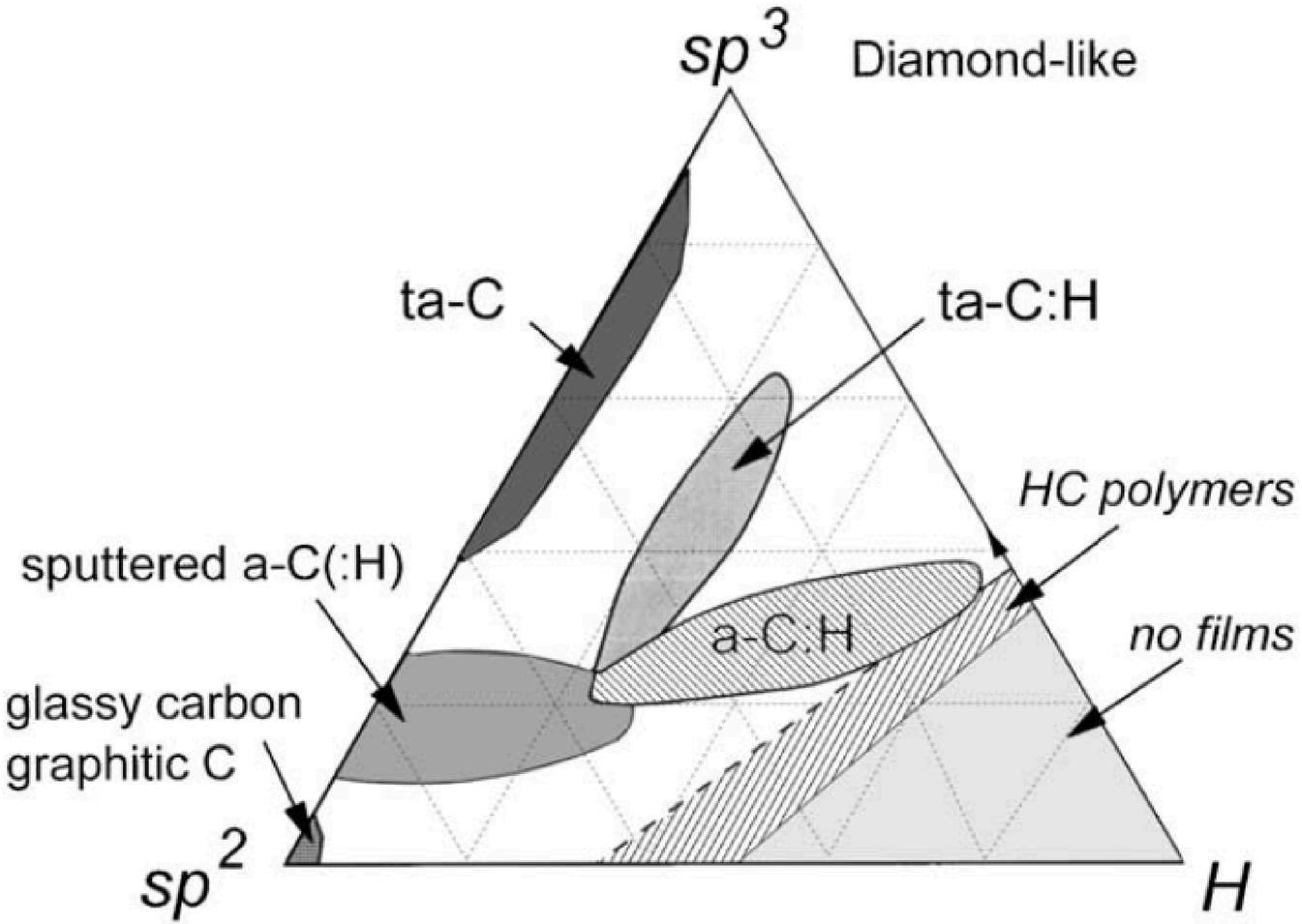
Thickness 0,01-2 µm

Sp^3 (diamond)

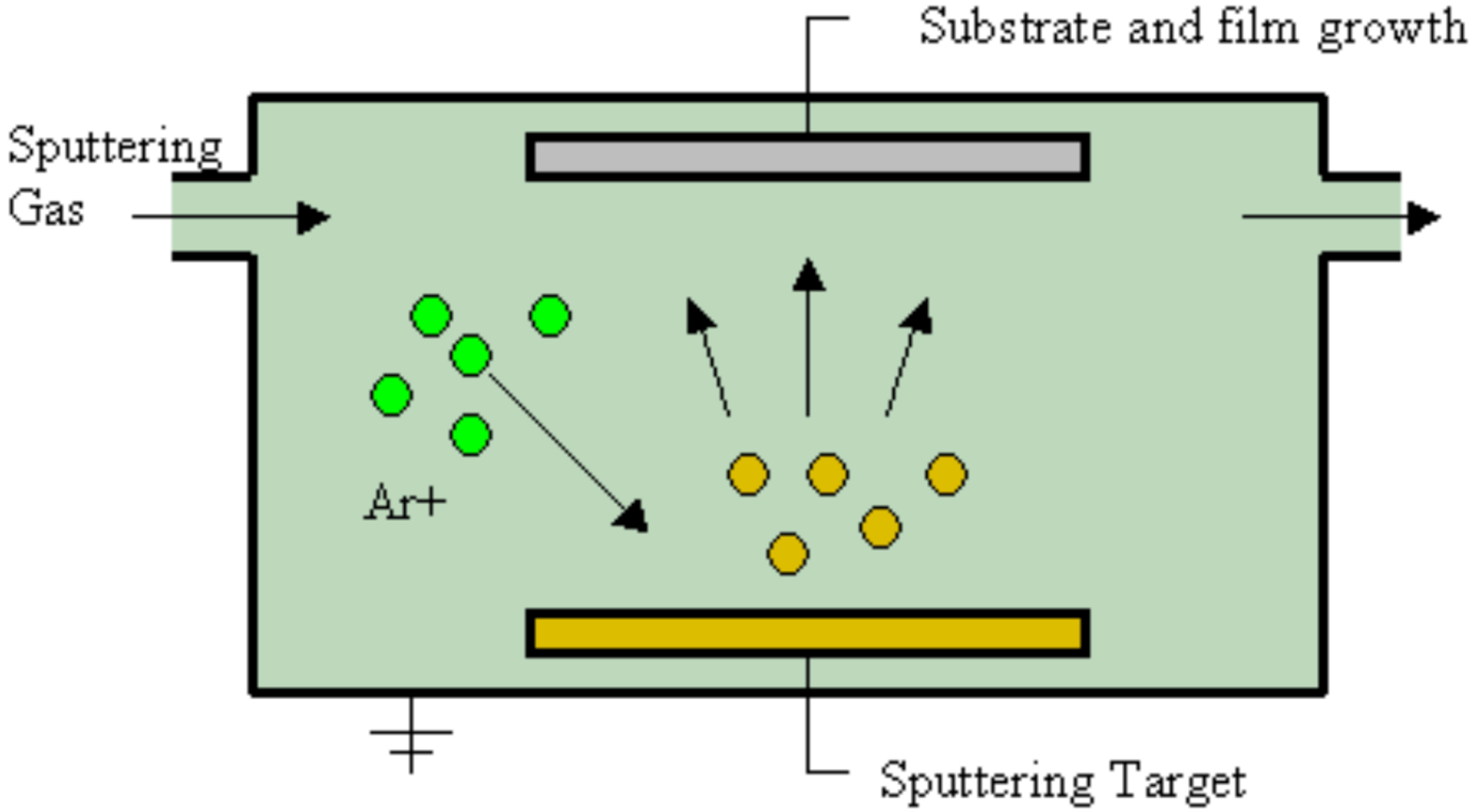
Sp^2 (graphite)

TERNARY DIAGRAM

- **ta-C (sp^3 80-88%)**
- **ta-C:H (sp^3 70% - H 30%)**
- **a-C:H (sp^3 40-60% - H 30-50%)**

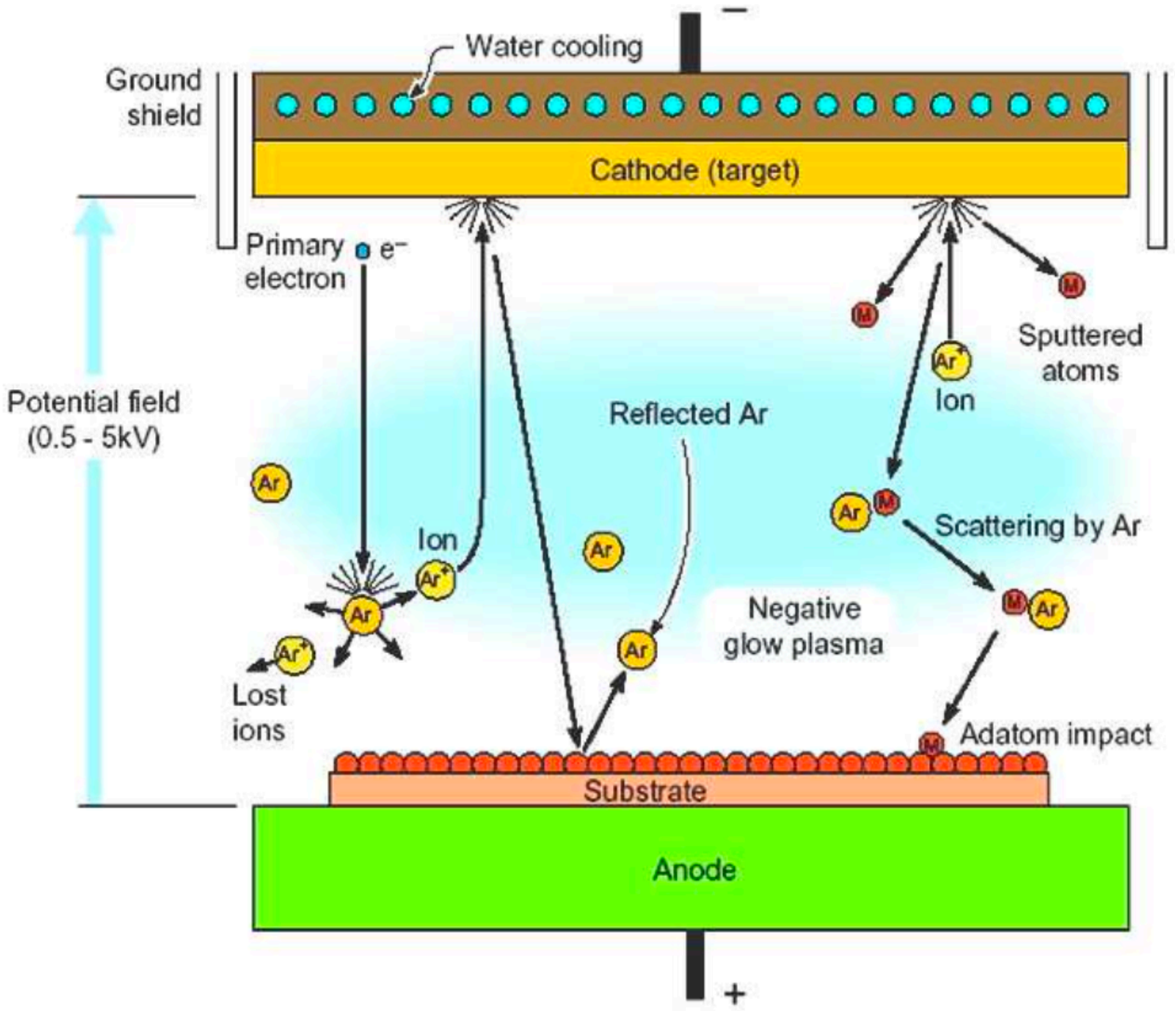


PVD - SPUTTERING



Atomic ejection
Kinetic Energy
Threshold energy

DC SPUTTERING

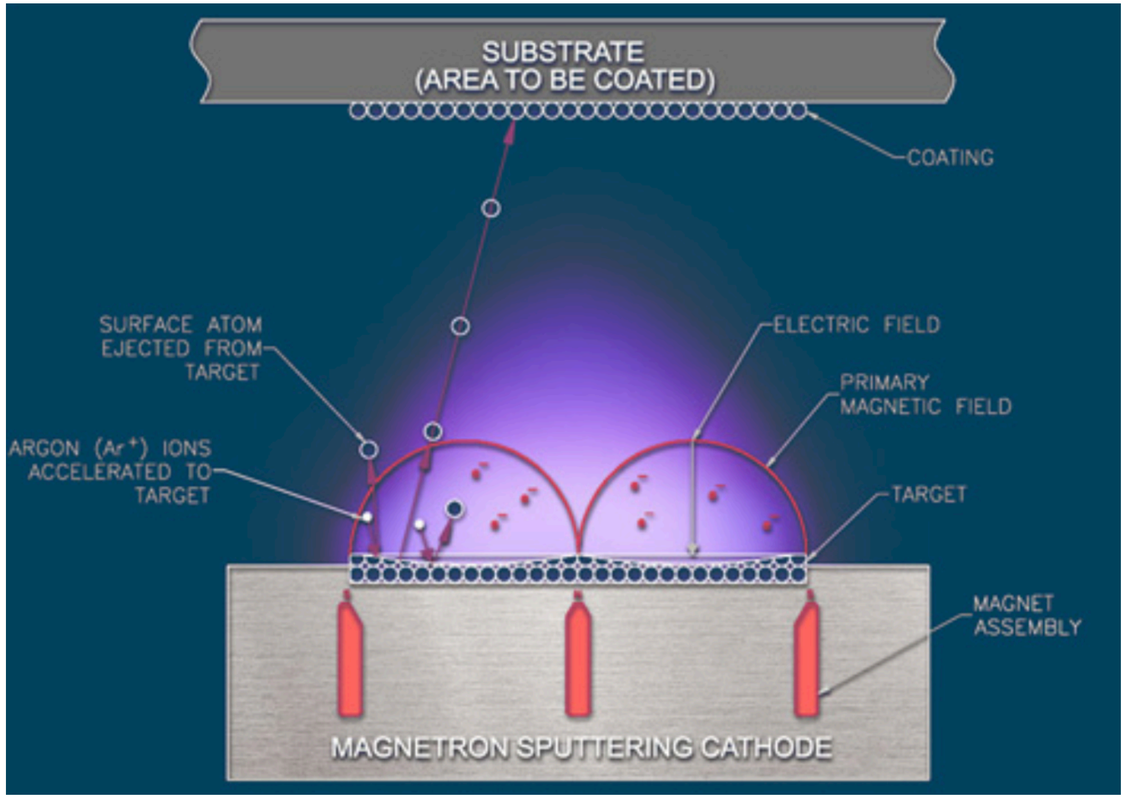


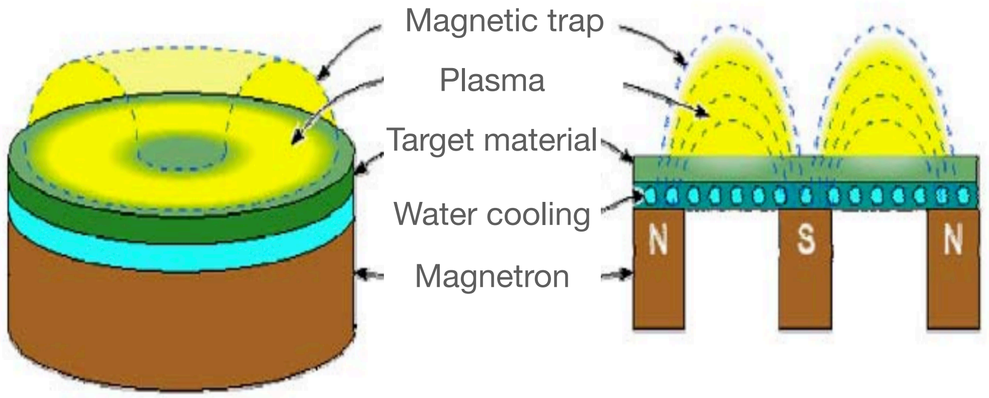
- **Target (cathode)**
- **Substrate (anode)**
- **UHV (10^{-7} Pa)**
- **0,5 - 5 kV**

GAS

Reactive **Non Reactive**

MAGNETRON SPUTTERING (MS)

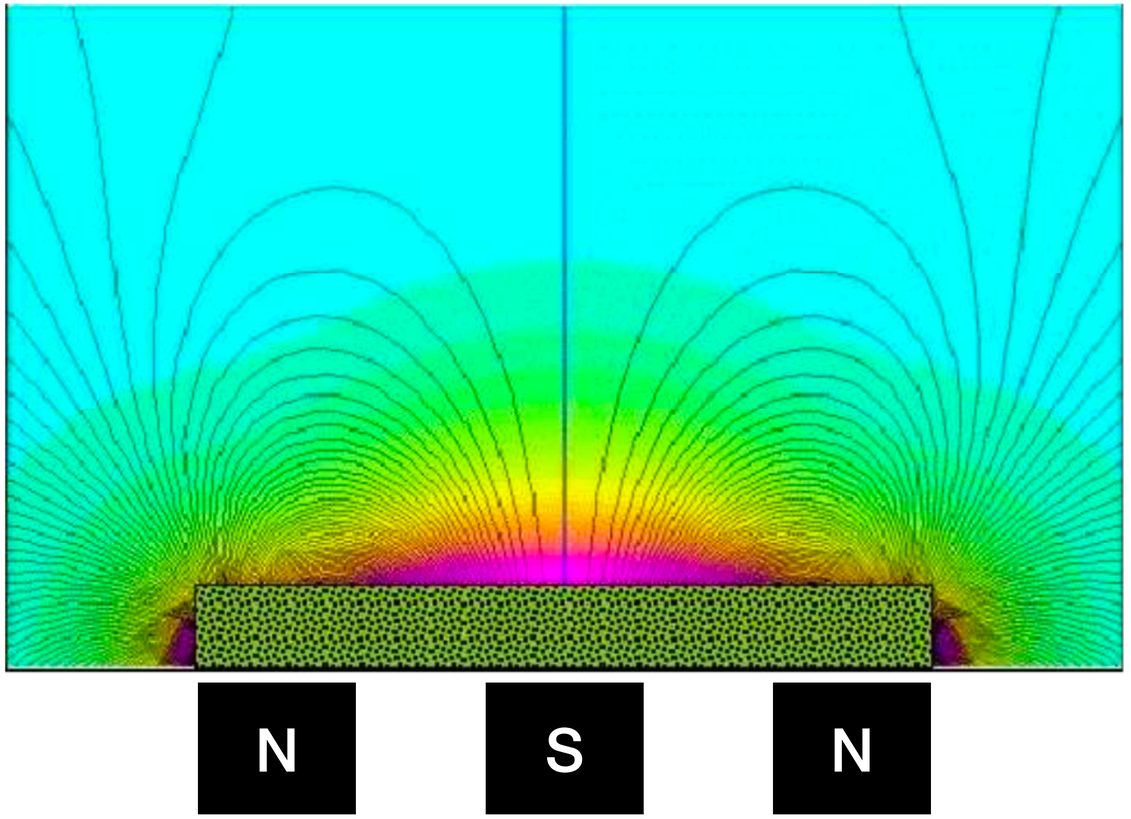




MAGNETRON SETTING

3 KIND OF MAGNETRON:

1. **BALANCED MAGNETRON**
2. UNBALANCED I
3. UNBALANCED II



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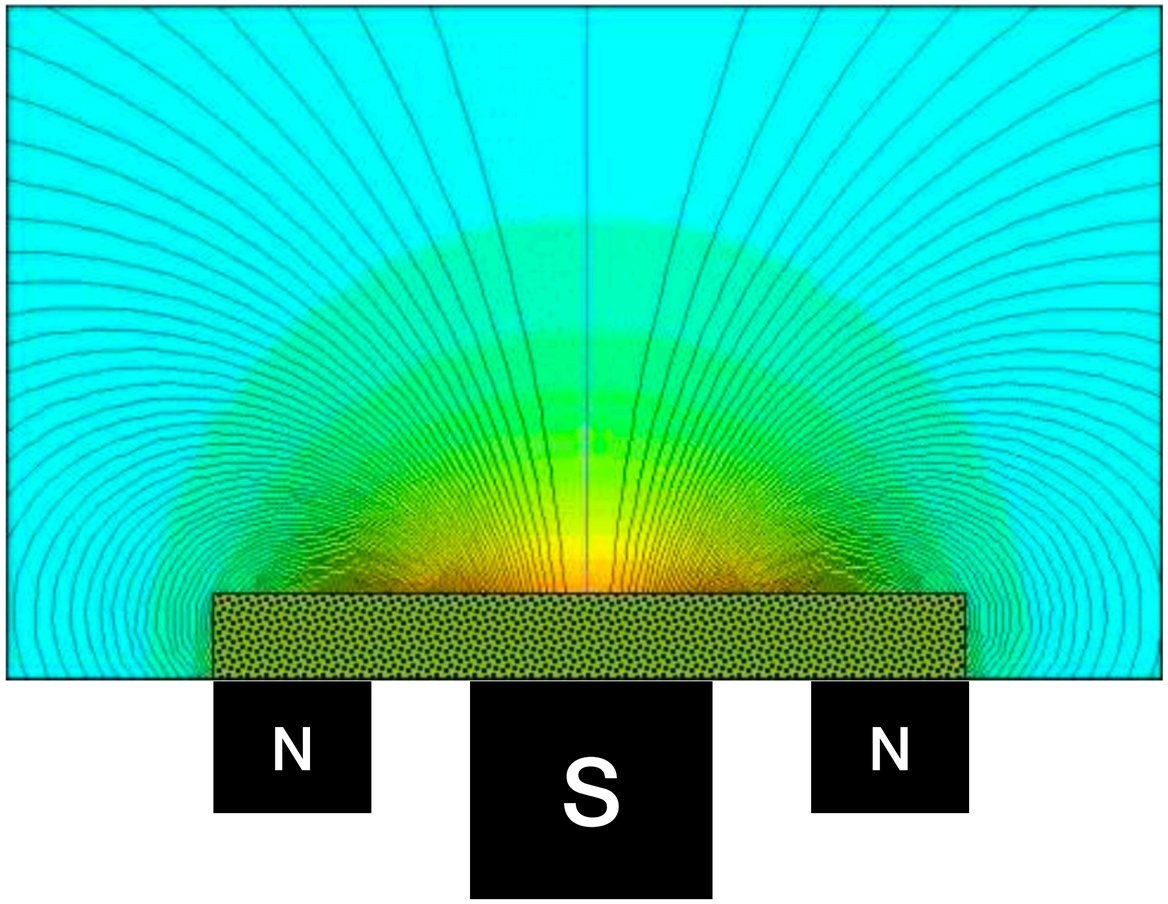

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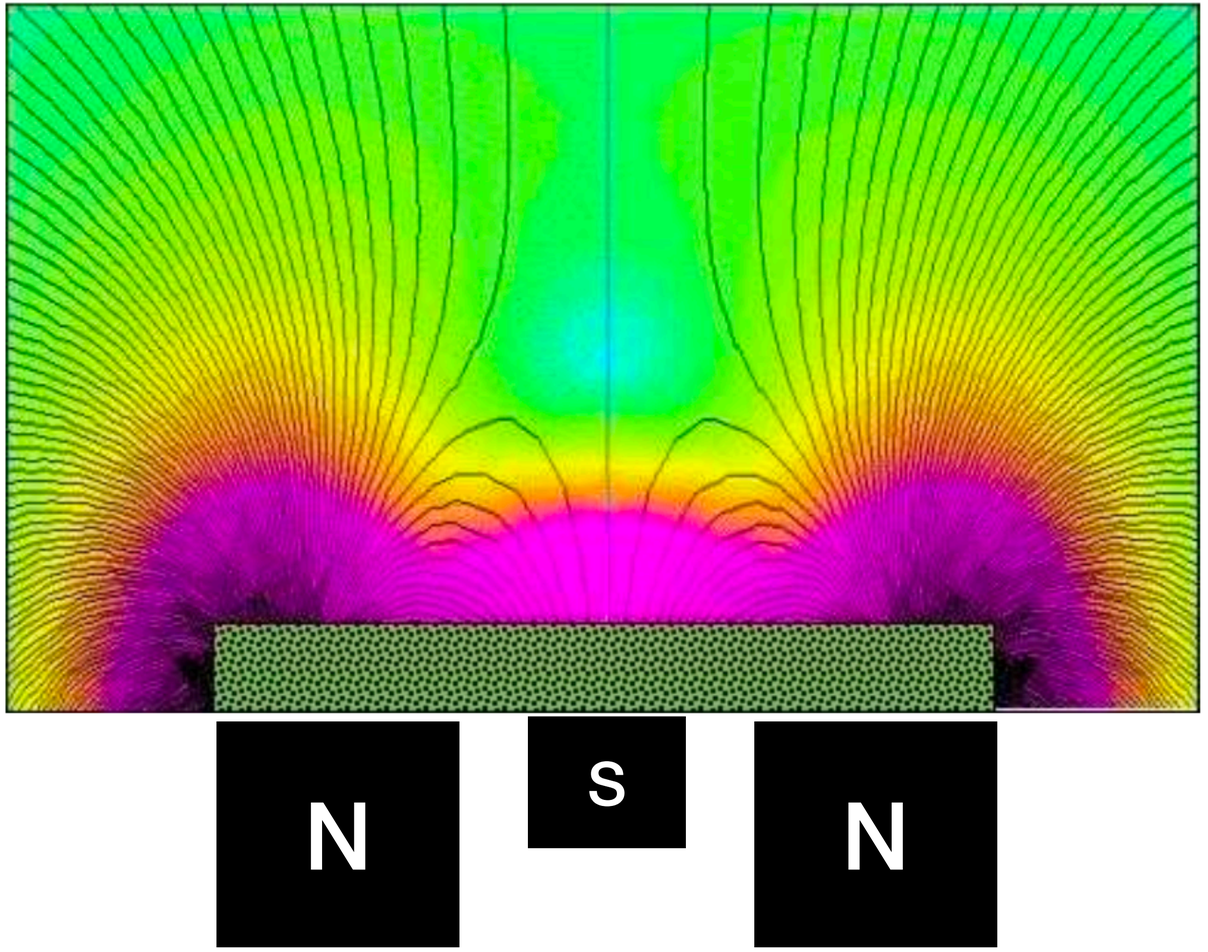
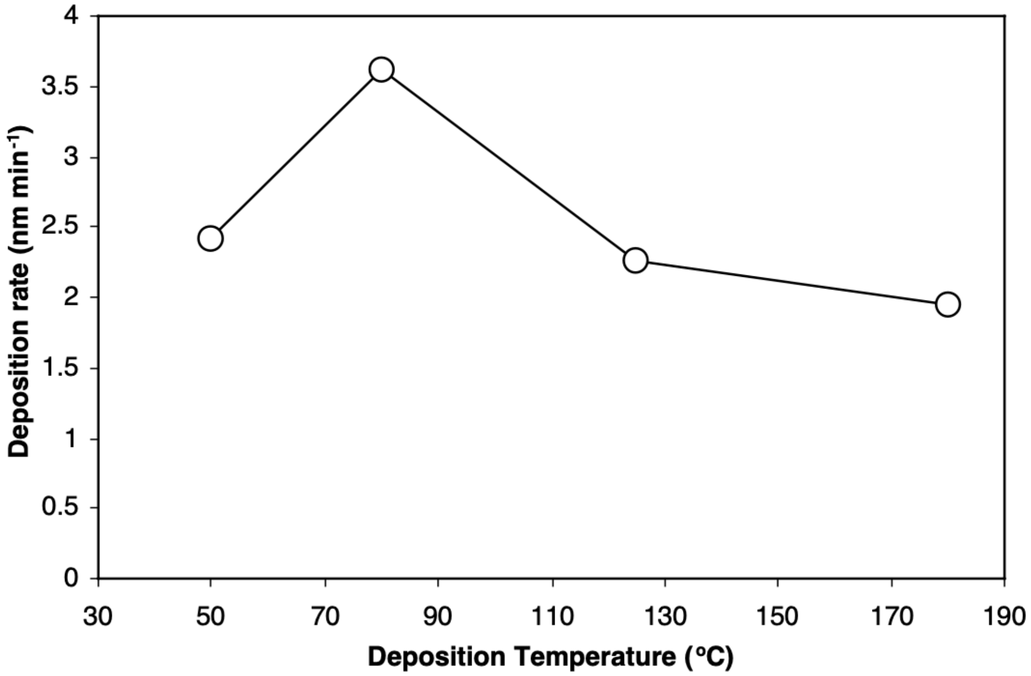


Experimental parameters:

Target: Graphite 75mm diameter
Substrate: Silicon wafer pre-sputtered
Gas: Argon pure (99,99%)
Working pressure: 10^{-3} Pa
Working Temperatures: 50, 80, 125 and 180 °C



From 50 °C to 80°C —> increase
Higher 80 °C —> decrease

RAMAN SPETTROSCOPY

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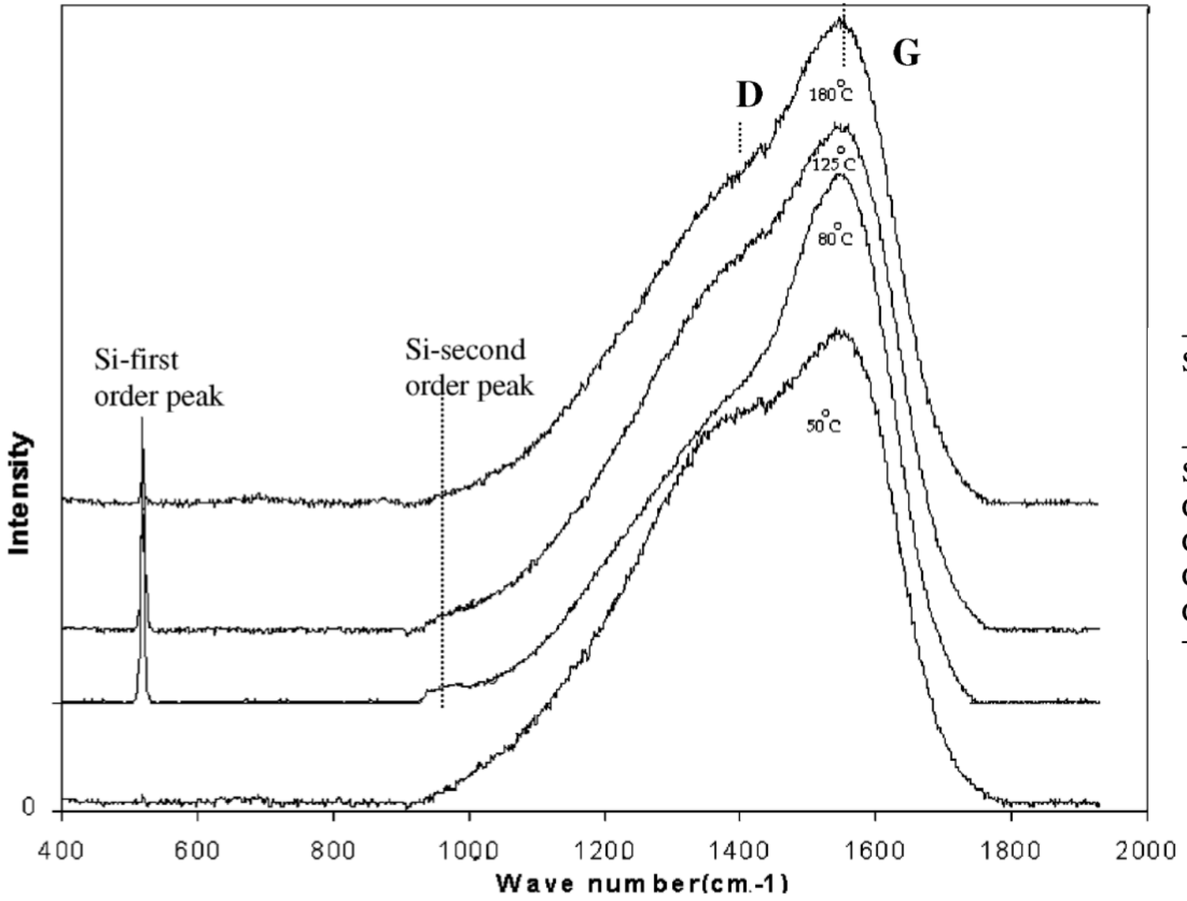
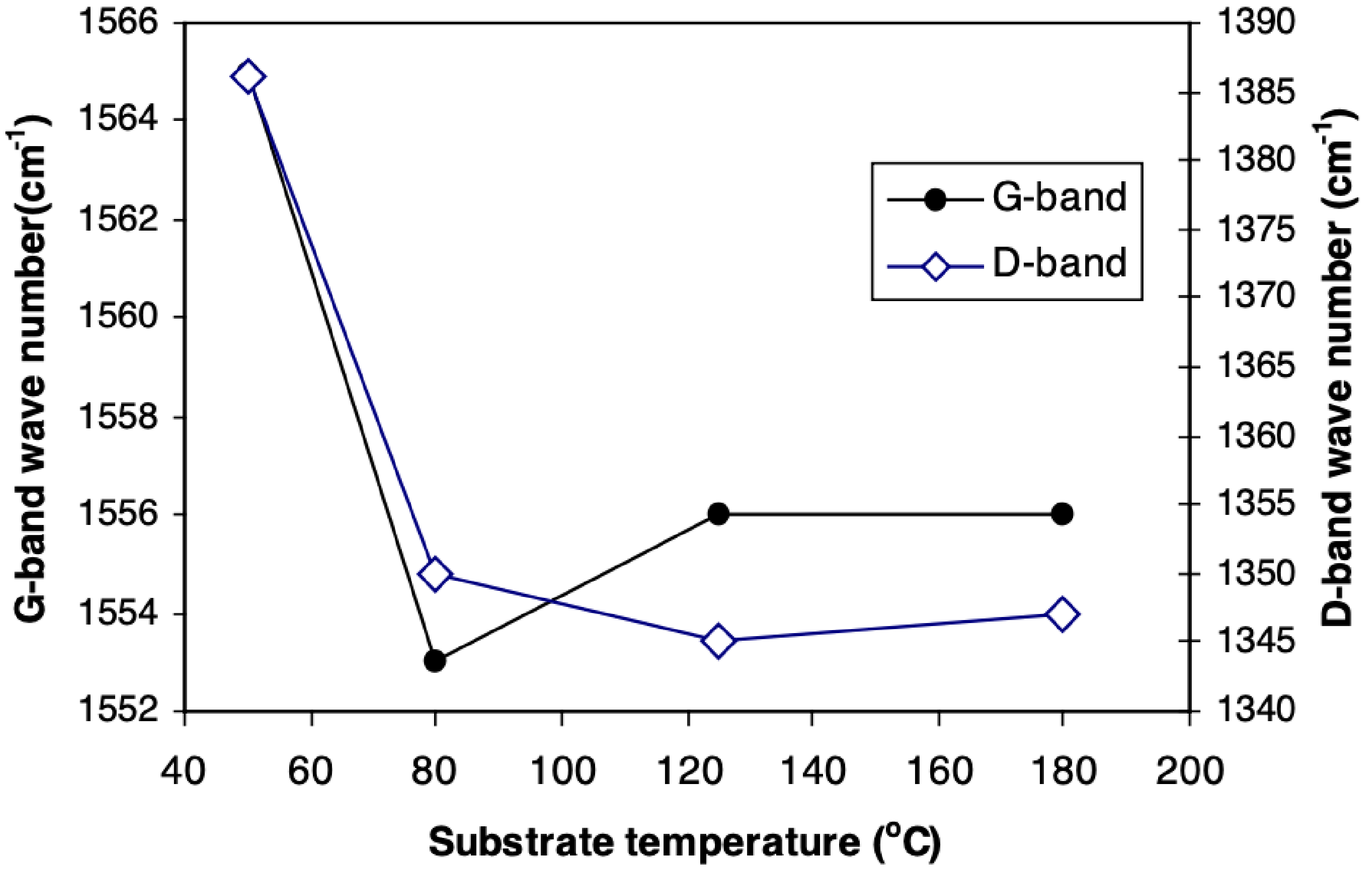


Raman spectra of the DLC films deposited at different substrate temperatures

Sample	Power (W)	Ar gas (Pa)	Temperature (°C)	Bonding properties		
				D peak (cm^{-1})	G peak (cm^{-1})	I_d/I_g
Silicon (100)	–	–	–	–	–	–
C-38			50	1386	1565	3.64
C-33	200	0.2	80	1350	1553	1.02
C-34			125	1345	1556	1.20
C-53			180	1347	1556	1.13

Experimental results for DLC films with different substrate temperatures using Raman spectroscopy

Beeman Model



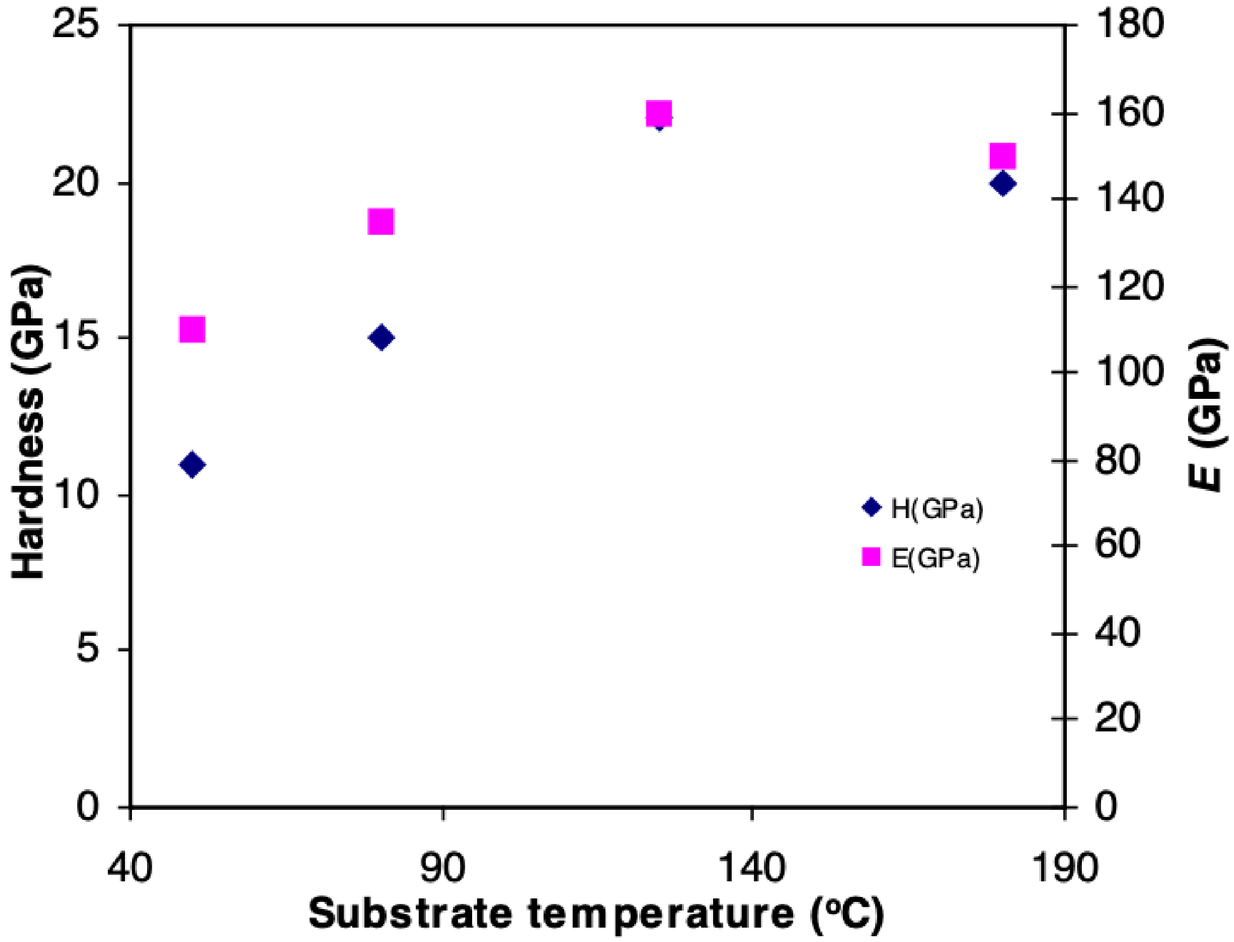
Beeman model to estimate sp^3/sp^2 ratio from G peak position

From 50 °C to 80°C —> sp^3 increase
Higher 80 °C —> sp^3 decrease

MECHANICAL PROPERTIES

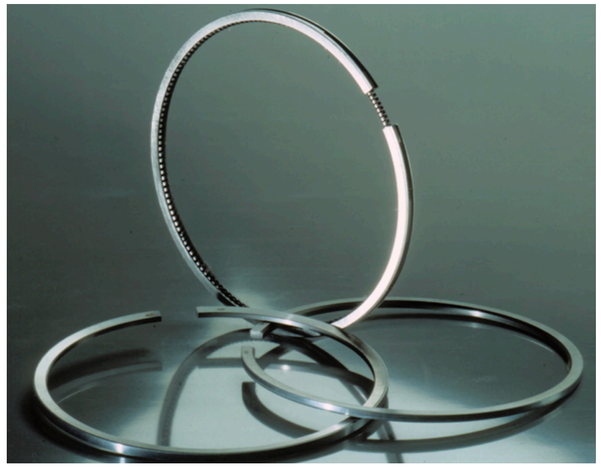
Vickers test + uniaxial traction test

Mechanical properties	
H (GPa)	*E* (GPa)
13	151
11	110
15	135
22	160
20	150

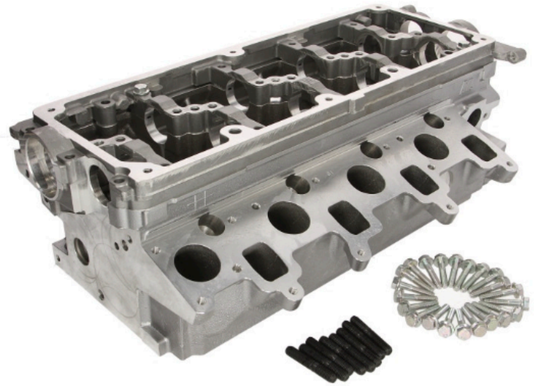


125°C higher order carbon atoms

MECHANICAL PROPERTIES



High hardness (H)



High elastic modulus (E)

Bibliography

- Coating Technology for Vehicle Applications - Sung Chul Cha • Ali Erdemir 2015, Springer
- DLC coating technology applied to sliding parts of automotive engine, Makoto Kano January 2006New Diamond and Frontier Carbon Technology: an International Journal on New Diamond, Frontier Carbon and Related Materials
- Diamond like carbon coatings for tribology: production techniques, characterisation methods and applications S. V. Hainsworth & N. J. Uhure
- Characterization of DLC coatings deposited by rf magnetron sputtering S. Chowdhury, M.T. Laugier*, I.Z. Rahman
- Preparazione e caratterizzazione di film di carbonio DLC - Tesi di Laurea Magistrale A.A. 2003-04, Dipartimento di Scienze Chimiche - N. Patron
- Fundamentals, overtones, and combinations in the Raman spectrum of graphite Yasushi Kawashima Department of Mechanical Engineering, Faculty of Engineering, Tokai University, Hi ratsuka, Kanagaura 259-12, Japan
- Raman studies on nanocomposite silicon carbonitride thin film deposited by RF magnetron sputtering at different substrate temperatures - Arnab Sankar Bhattacharyya, Suman Kumari Mishra - National Metallurgical Laboratory, Jamshedpur- 831007