Title
Preparation by pulsed vacuum arc deposition and characterization of DLC/MoS2 nanocomposite thin films

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Preparation by pulsed vacuum arc deposition and characterization of DLC/MoS_2 nanocomposite thin films

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Outline

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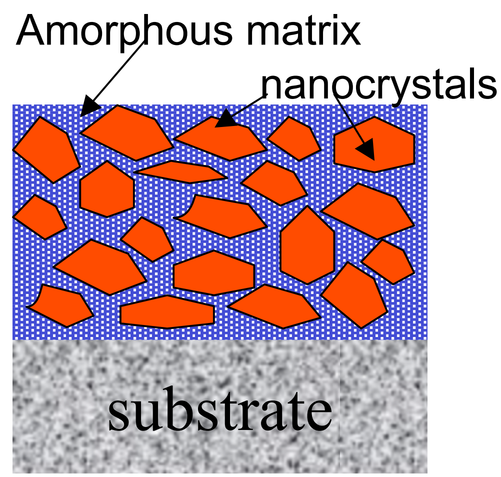
- Set-ups
- Thermodynamics
- C + Mo + CS_2: bonding
- Mo + S:
  - Bonding and structure
  - Ball-on-disk tests under air and dry nitrogen
- Mo + S + C:
  - Bonding and structure
  - Ball-on-disk tests under air and dry nitrogen
- Comparison with other systems and conclusions

Why DLC + MoS_2 nanocomposites

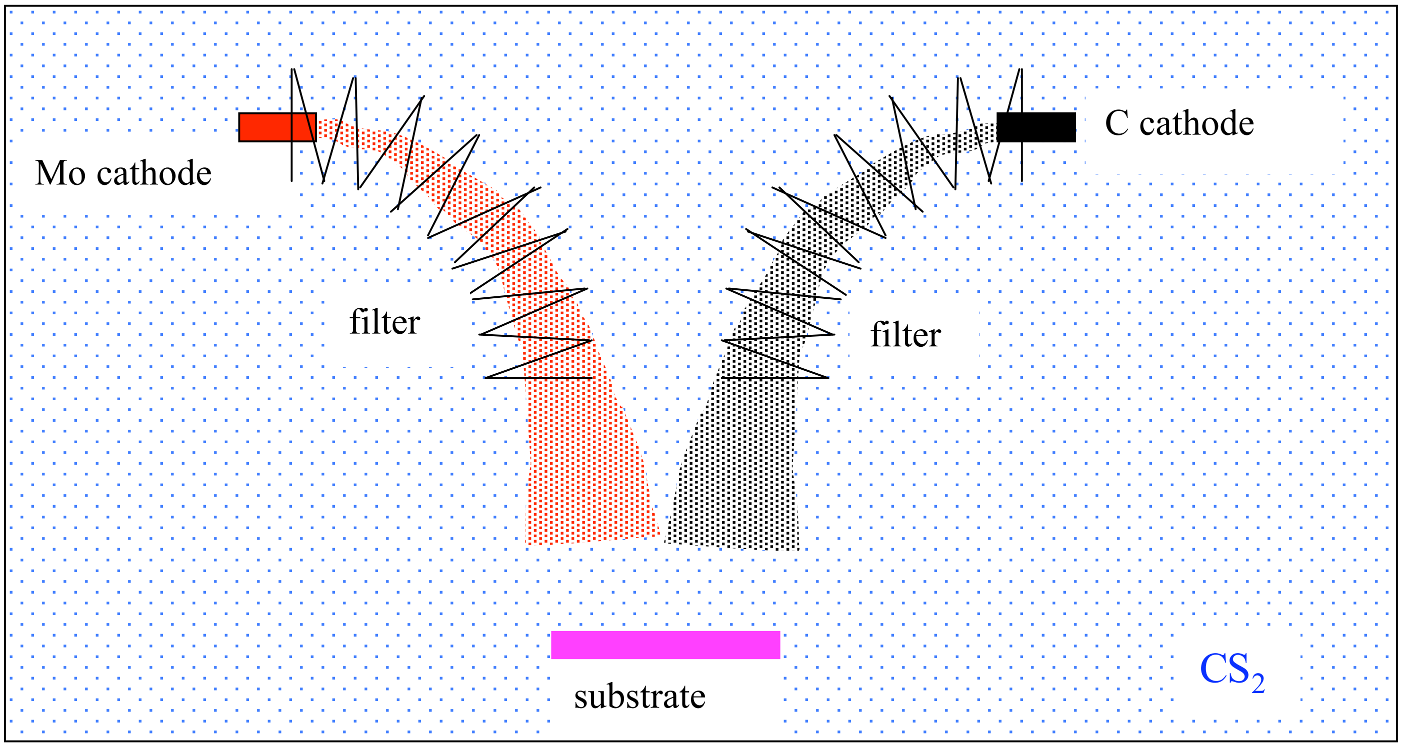
- Lubrication performances of non-hydrogenated DLC are limited in absence of moisture but good hardness and thoughness
- MoS_2 = good lubricant under dry conditions or under vacuum but low hardness, and oxydation in presence of O_2 or H_2O

=> idea: incorporate clusters of MoS_2 in a matrix of DLC to get a film with good performances under wet and dry conditions.



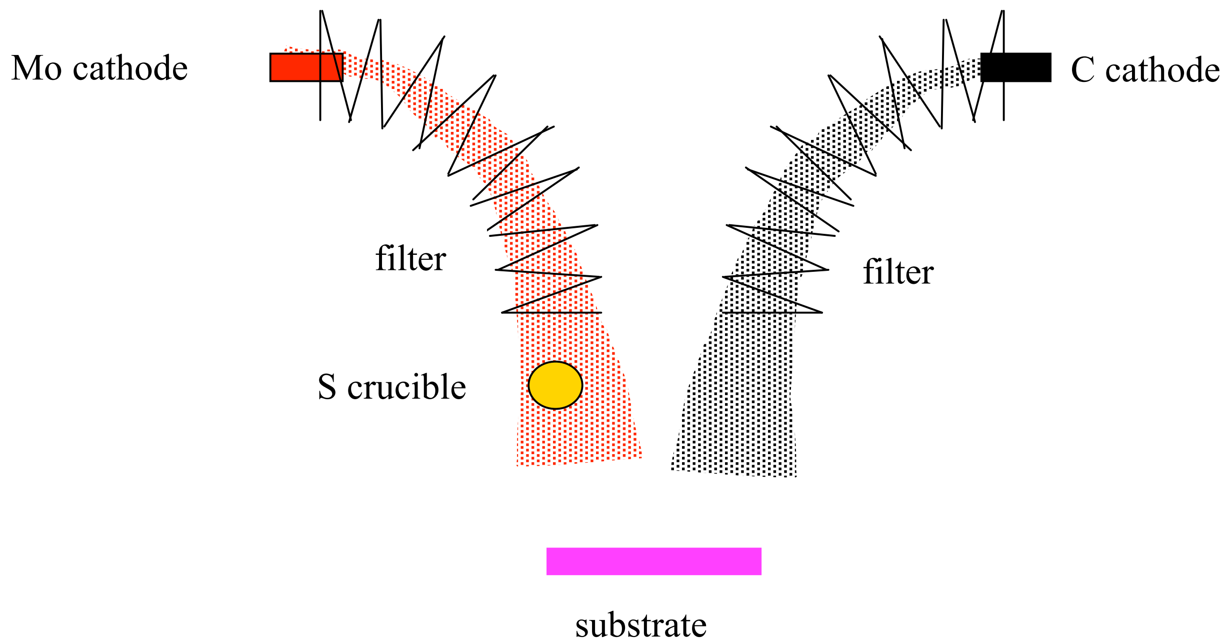
Set-up: gaseous source of Sulfur

- Gaz source for S = CS_2



Set-up : solid source of Sulfur

- Evaporation of solid sulfur in a crucible



Thermodynamics

CompoundEnthalpy of formation (at 298 K)MoS^2 solid-276.010 k	

In absence of S source

- C pulse 4 ms at 270A,
  Mo pulse 6 ms at 100A

=> formation of
molybdenum carbide

Films prepared with CS_2

- C pulse 4 ms at 270A,
  Mo pulse 6 ms at 100A
  1 Pa of CS_2

=> - very low incorporation of sulfur
- difficulty to control the Mo/C and S/C ratios
- sensitivity to contamination

Mo + S synthesis: bonding

- sulfur is incorporated exclusively if Mo is present
- a bias on the substrate reduces the incorporation of sulfur in the film. Two factors:
  - preferential sputtering of sulfur under Mo^{n+} ion bombardment
  - the bias attracts the Mo^{n+} ions but as the ionization of sulfur is low, the bias is not attracting the sulfur
- the structure is not well ordered: wide peaks in XPS

MoS_2 synthesis: mechanical properties

- Ball-on-disk tests in dry N_2, Al_2O_3 ball
  - life time increased by a factor of 4 in comparison with air tests
  - failure by delamination and intensive cracking

=> very brittle films

=> not satisfactory as lubricants even under dry N_2

Mo + S + C: bonding

- S bonded mainly to Mo.
- No real proof of C-S bonds even in presence of an excess of S
- possible S-S bonds in presence of an excess of S
- in presence of an excess of Mo formation of MoO_3 at the surface and tendency to form Mo-C bonds in the bulk
- reduction of S incorporation in presence of bias

Mo + S + C: mechanical properties

- Ball-on-disk tests with stainless steel and alumina balls in air
- Ball-on -disk tests with alumina balls in dry N_2

=> best resistance to abrasion in air and dry N_2 for low concentration of MoS_2 (doping).

=> at low concentration of MoS_2 (doping), better resistance to abrasion with a steel ball than with Al_2O_3 ball

=> performances are lower in air than pure DLC films

=> films with high MoS_2 concentration are brittle and don 't support the load: extensive cracking and delamination

NO improvement of the tribological performances of DLC by the addition of MoS_2 in the deposition conditions investigated here.

Comparison with other systems and conclusions

- The MoS_2 / DLC system has been compared with W doped DLC and Ti doped DLC films prepared in similar conditions:

=> W and Ti additions reduce the intrinsic compressive stress of the hard DLC films and made them thougher.

=> addition of MoS_2 does not improve the performances of doped DLC films, it increases the brittleness: could be related to the bonding in the films.