MITSUDA LAB.

[Fabrication of Carbon Allotropes Films]

Department of Materials and Environmental Science

Inorganic Plasma Syntheses

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Carbon Films?

Allotropes of Carbon

Various types of Carbon

Since carbon has various crystal structures depending on the bonding state, several allotropes exist. Many amorphous (microcrystalline) carbon substances are also known.

Crystalline Phase

- Diamond（High Pressure Phase）
  - Carbon Bonding：only sp^3
- Graphite（Normal Pressure Phase）
  - Carbon Bonding：only sp^2
  - Single Layer：Graphene
  - Deformation：Nanotube
- Carbyne（Super High Pressure Phase）
  - Carbon Bonding：only sp
- Fullerene
  - Intermediate of sp^3 and sp^2

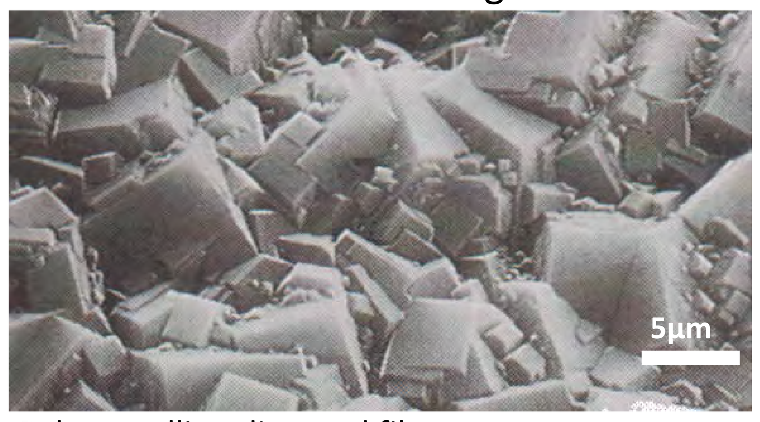
Amorphous Phase

- Diamond Like Carbon（DLC）
  - Carbon Bonding：Mixture of sp2 and sp3
  - Amorphous Phase with Diamond Properties
  - Ideal：Transparent・Hard・Insulating
- Glassy Carbon
  - Graphite with Disordered Layer Structure
- Carbon Black
  - Fine crystalline Graphite
- Soot
  - Fine crystalline Graphite

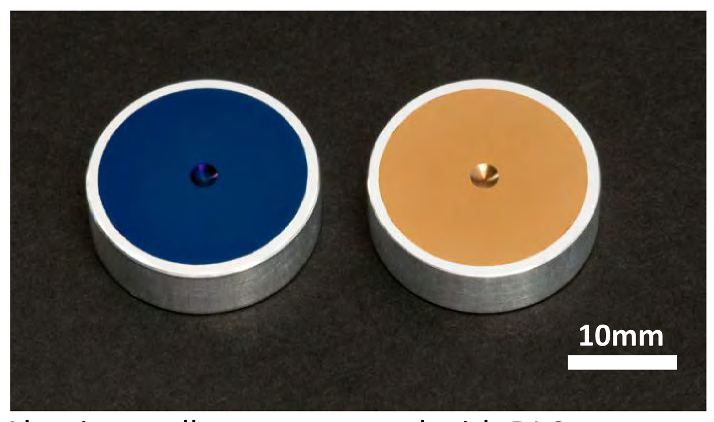
Diamond & DLC

Hard Coating Films of Carbon

Both diamond vapor phase growth and DLC film fabrication started research from the 1960's. Diamond film is a next generation material that is expected to be practical use as a superhard film or semiconductor film. DLC film has already been practical use as a hard film or a barrier coating.



Polycrystalline diamond film.
A square (100) can be observed. Since the crystal habits clearly appear, the surface roughness of film is huge.



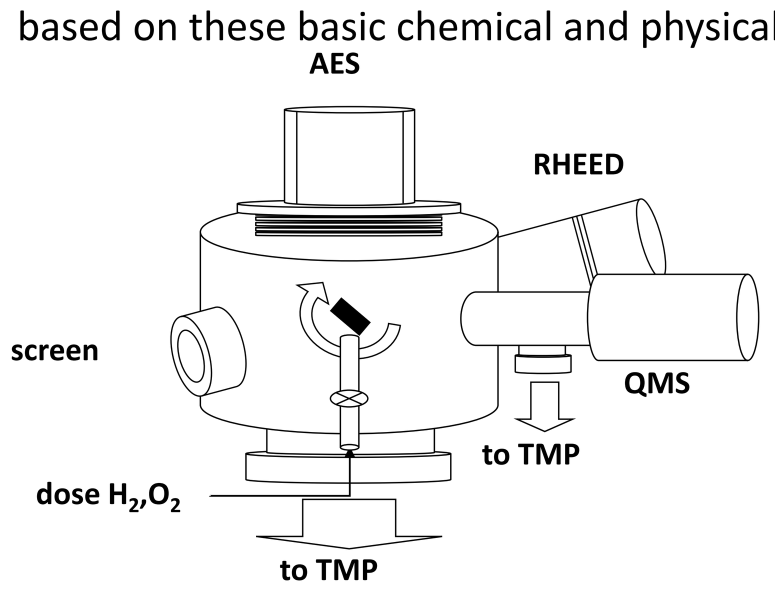
Aluminum alloy parts coated with DLC.
Differences in color are caused by interference depending on the film thickness. This indicates that DLC is transparent in the visible light region.

Diamond Growth from Vapor Phase

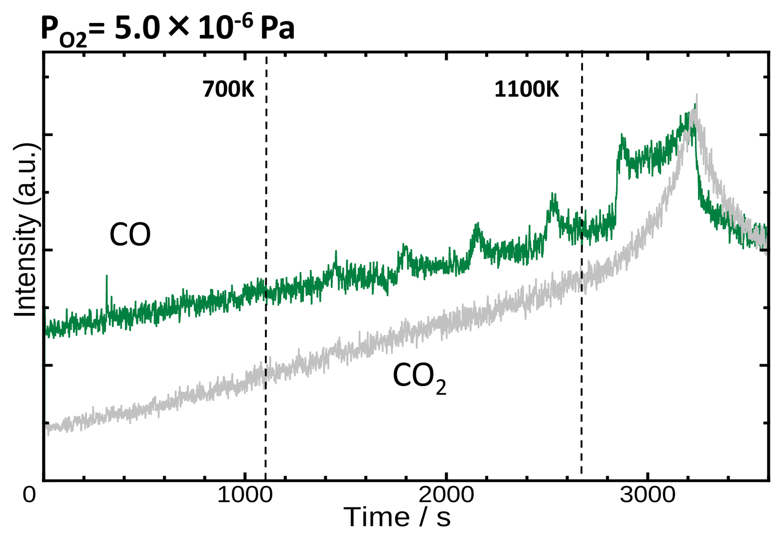
Surface Reaction during Diamond Vapor Growth

Mechanism of Diamond Growth

Diamond surface interacts with various vapor phase molecules during vapor phase growth. The mechanism of diamond growth from the vapor phase will be established based on these basic chemical and physical analyses in ultra high vacuum.



Schematic diagram of the surface analysis chamber. The base pressure < 10^{-9} Pa is achieved inside the chamber. AES, RHEED, QMS, and heated gas sources enable the surface modification and analyses of desorbed species



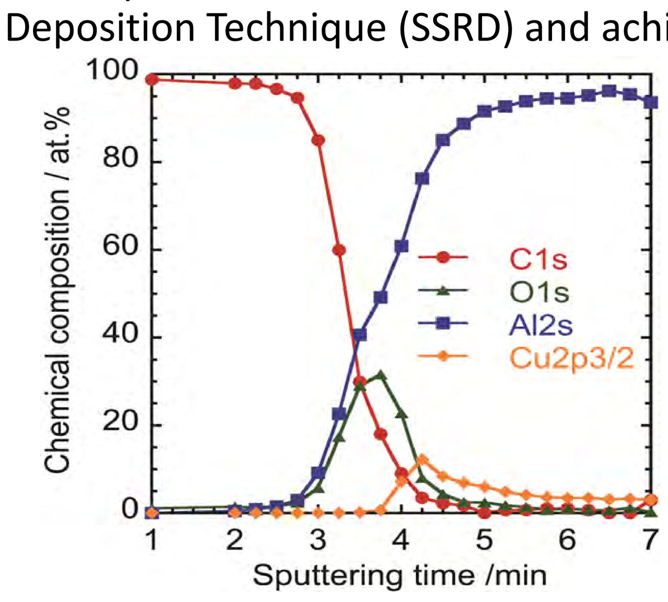
Desorption species from diamond during a thermal annealing in oxygen. Oxygen on the diamond surface is always detected as CO when it is removed from the surface.

Fabrication of Amorphous Carbon

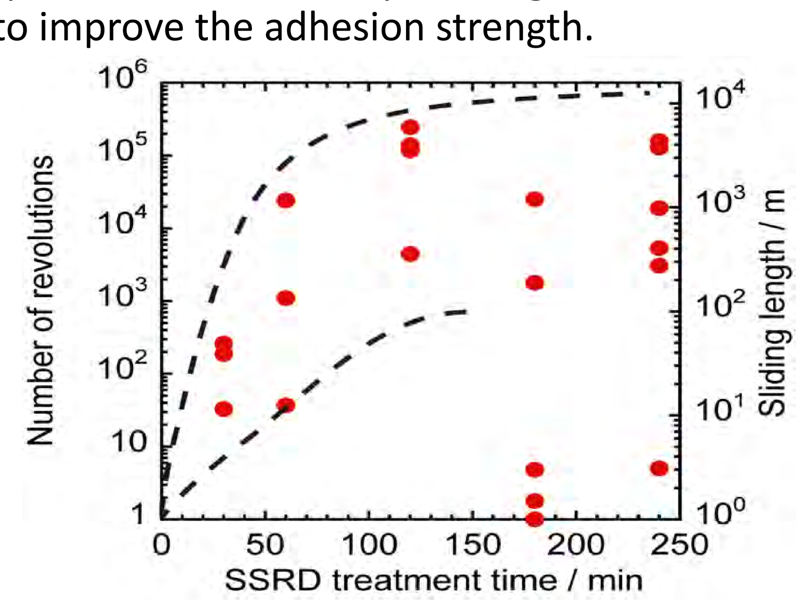
Wear-proof Coating of DLC on All alloy

Improvement of Adhesion Strength & Tribrogical Behavior

When surface hardness of Al is improved by DLC coating, a lightweight mechanical sliding part is realized, although there is a problem of low adhesion. We have developed a novel interfacial control technique called Substrate Sputtering Re-Deposition Technique (SSRD) and achieved to improve the adhesion strength.



XPS measurement result near the interface between DLC film (left) and Al alloy substrate (right). By the SSRD method, an Al/C mixed layer is formed near the interface.



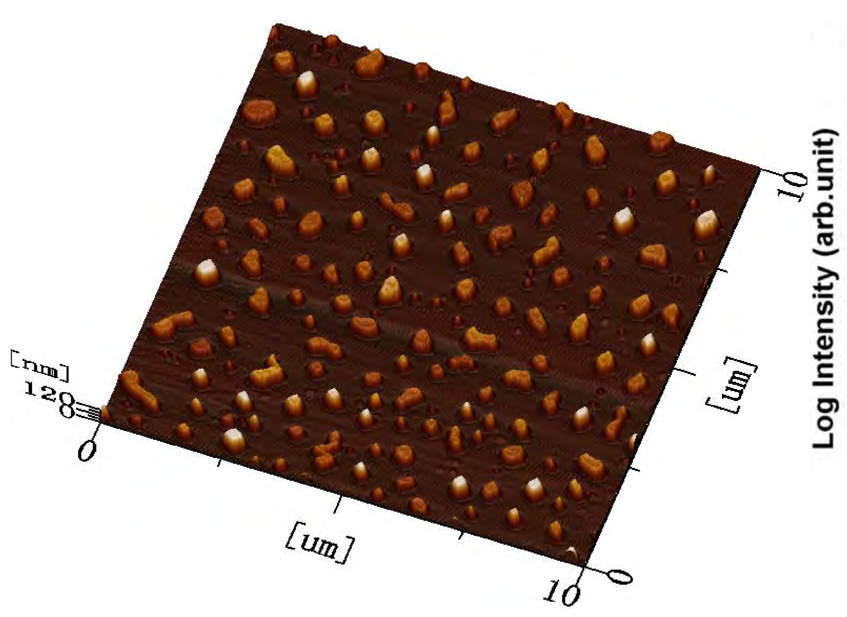
Ball on disk test results of DLC film deposited on Al alloy by SSRD method.
According to the SSRD duration, the durability is improved.

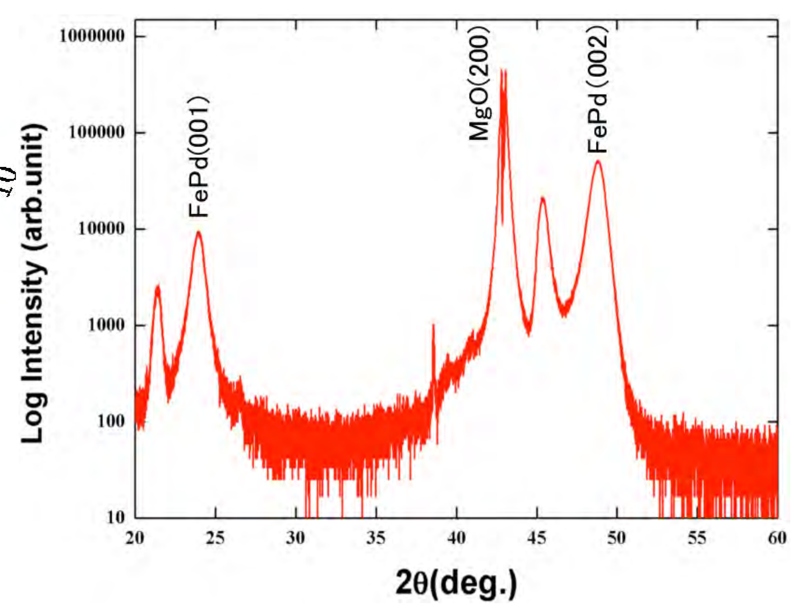
Other Research Topics

Self-assembled Nanostrutures

Driving by Surface Energy

Thin films with self-assembled nanostructures are formed by a bottom-up process based on the sputtering. These structures are applicable for the magnetic data storage devices.



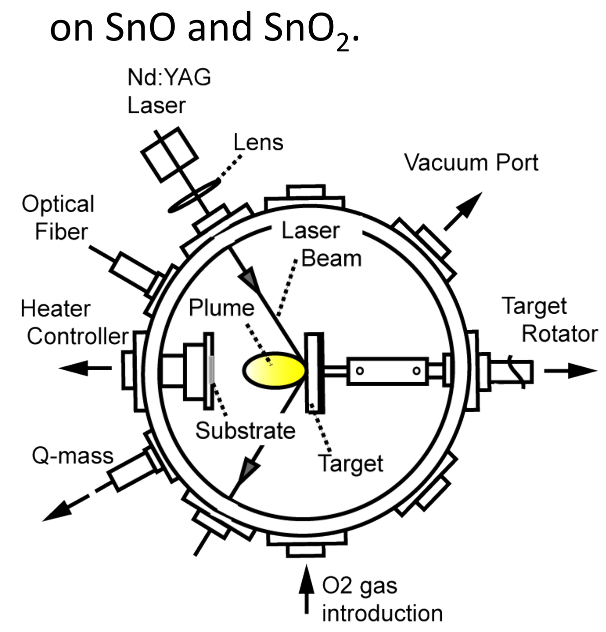


FePd nanodots with diameters of a few tens of nm were formed through the deposition of Fe seeding layer and Au agglomeration layer on a single crystalline MgO substrate. AFM image and X-ray diffraction pattern show oriented crystals and an uniform size of the FePd dots.

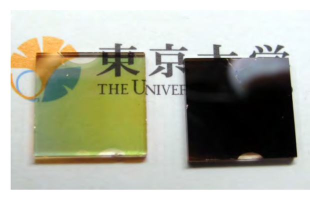
Transparent Conductive Films

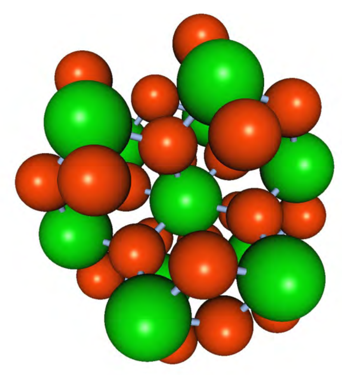
Oxide Film Deposited by Pulse Lase Deposition

Transparent and conductive oxide (TCO) films are essential for flat panel displays and solar cells. We are trying to realize a novel TCO with high electrical conductivity based on SnO and SnO_2.

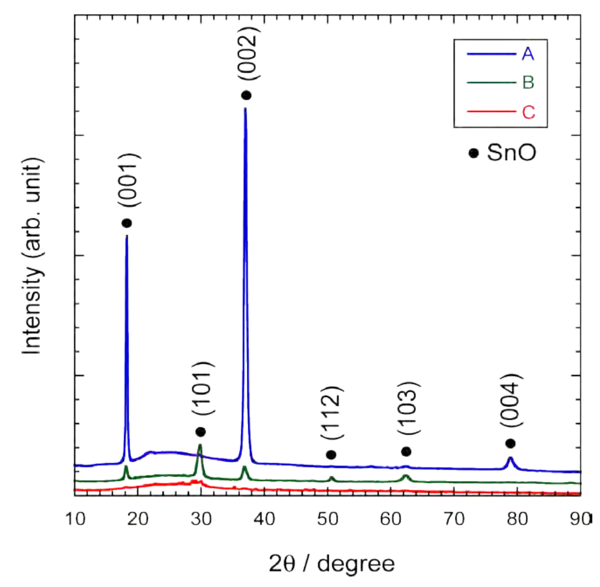


Pulsed-laser deposition chamber with a Nd-YAG laser. The base pressure reaches 10^{-7} Pa.





New candidate elements for the impurity doping are explored by a model simulation.



Oriented crystalline of SnO films were achieved on a glass by controlling oxygen and Sn flux during the film deposition.