Materials Characterization

Master in Nanotechnology

Characterization of MPE PLI-CVD low temperature distributed antenna array Diamond Thin Films from Tequila

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Outline

Introduction

How are diamond films synthetized and what are they used for

Which role plays characterization

Morphological characterization

Characterization of optical properties and further uses

Conclusions

Introduction

- Diamond, a material with extreme physical, chemical, biocompatible and electrical properties, which are widely used on new generation devices.
- Diamond films properties.
- diamond films can also be used as a radiation shield and a radiation sensor.
- Thermoluminiscent properties of diamond after being irradiated by beta radiation, which damage biological tissue.

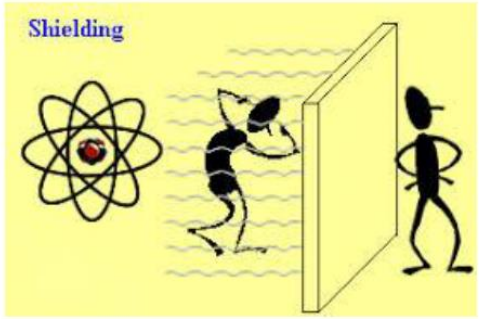
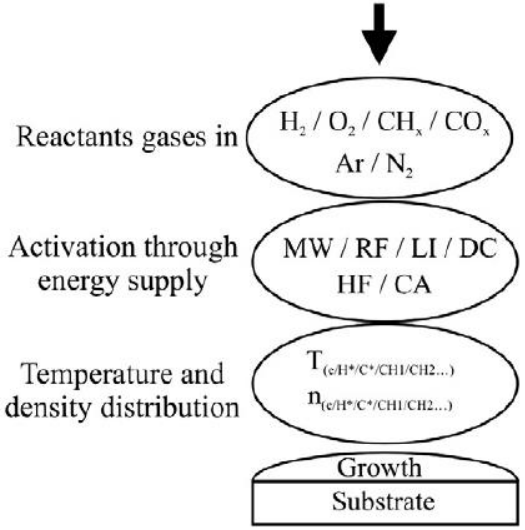


Image obtained from: https://www.hko.gov.hk/education/dbcp/rad_protect/eng/r4.htm

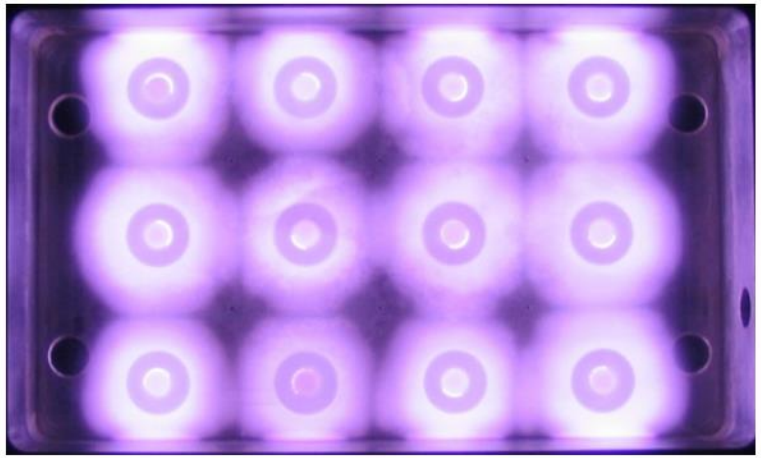
Table 1
Possible applications of nanocrystalline diamond films

	Nanocrystalline diamond
Electronic	− − Poor mobility [18]
Thermal management	+ + Very high thermal conductivity [3]
MEMS	+ + Highest Young's modulus, outstanding resonant frequencies [12, 47, 78]
Tribology	+ Low friction and roughness if grown thin [13]
Optical	+ + Highly transparent (undoped) [18]
Electrochemistry	+ + Transparency allows spectro-electrochemistry [73]
Acoustics (SAW, BAW, FPW etc.)	+ + High SAW velocity [3], TSM realised [62], see MEMS

Table obtained from: O. Williams, M. Nesladek, M. Daenen, S. Michaelson, A. Homan, E. Osawa, K. Haenen, and R. Jackman, "Growth, electronic properties and applications of nanodiamond", Diamond and Related Materials, vol. 17, no. 7, pp. 1080 {1088, 2008, Proceedings of Diamond 2007, the 18th European Conference on Diamond, Diamond-Like Materials, Carbon Nanotubes, Nitrides and Silicon Carbide, issn: 0925-9635. doi: https://doi.org/10.1016/j.diamond.2008.01.103. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0925963508001453.



Schematic diagram of the mechanism from CVD processes for diamond growth.

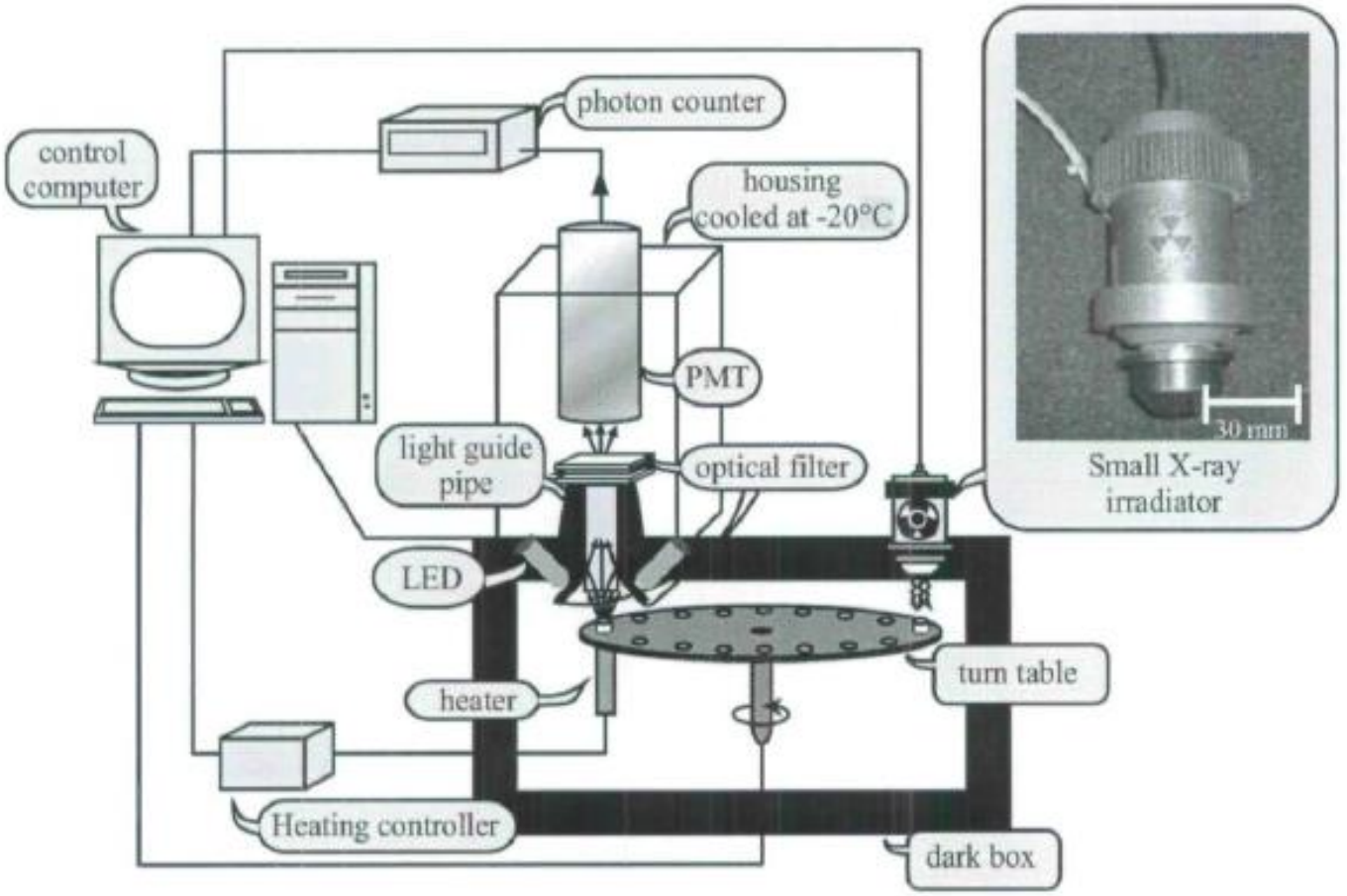


How are diamond films synthetized and what are they used for

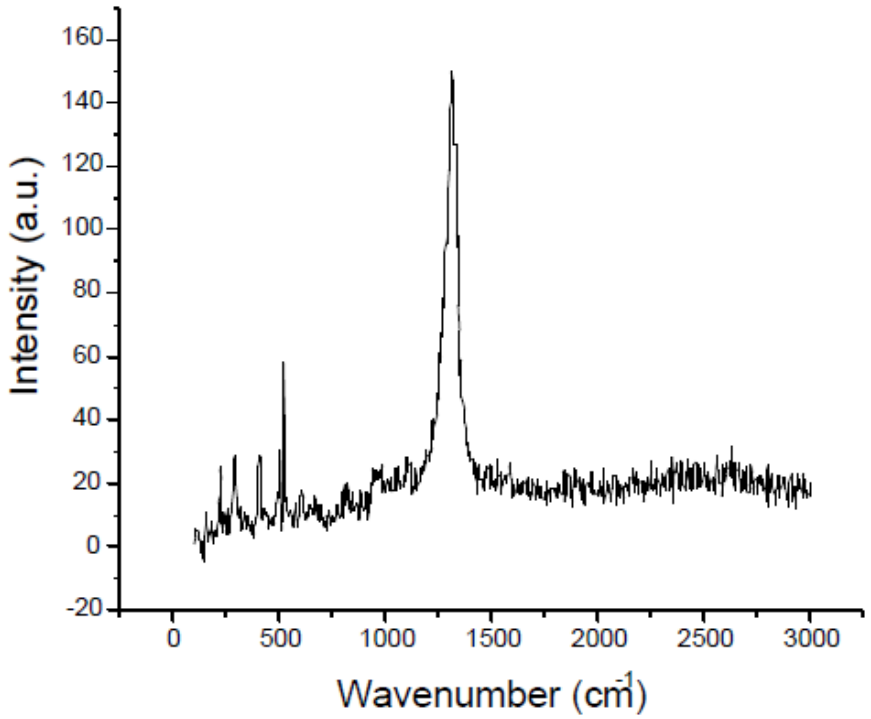
- Large scale coat on diverse materials towards radiation shield.
- MPE PLI CVD
- Precursor: Tequila
- Pressure of the reactor
- Injection frequency
- Microwave power
- Surface temperature range

Which role plays characterization

- Sample preparation required
- Predictable properties



Picture obtained from: https://sites.google.com/site/103f13dating/thermoluminescence



Obtained from: J. Morales-Castillo, M. Apatiga, and V. Castaño, “Growth of diamond films from tequila", vol. 21, Jul. 2008.

Morphological characterization

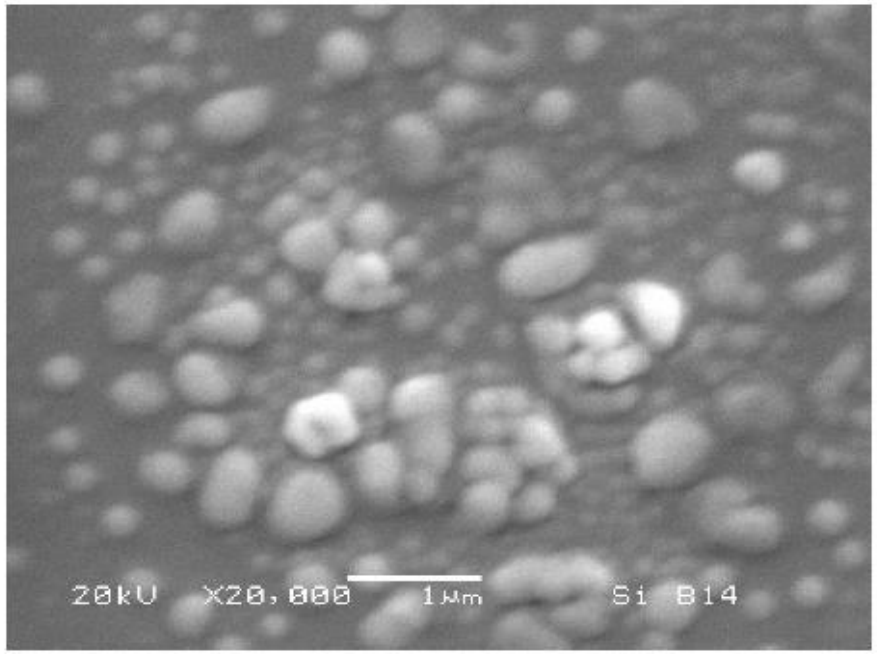
Raman

- Purity
- Trans-polyacetylene responses at around 1140 cm^{-1} and 1480 cm^{-1}
- The sp^3 fraction
- Full width at half maximum (FWHM) of the 1332 cm−1 diamond peak. Grain size, structural disorder

$$sp^3(\%) = 100 \cdot \left(\frac{60 \cdot I_{diamond}}{60 \cdot I_{diamond} + \sum I_{non\ diamond}} \right)$$

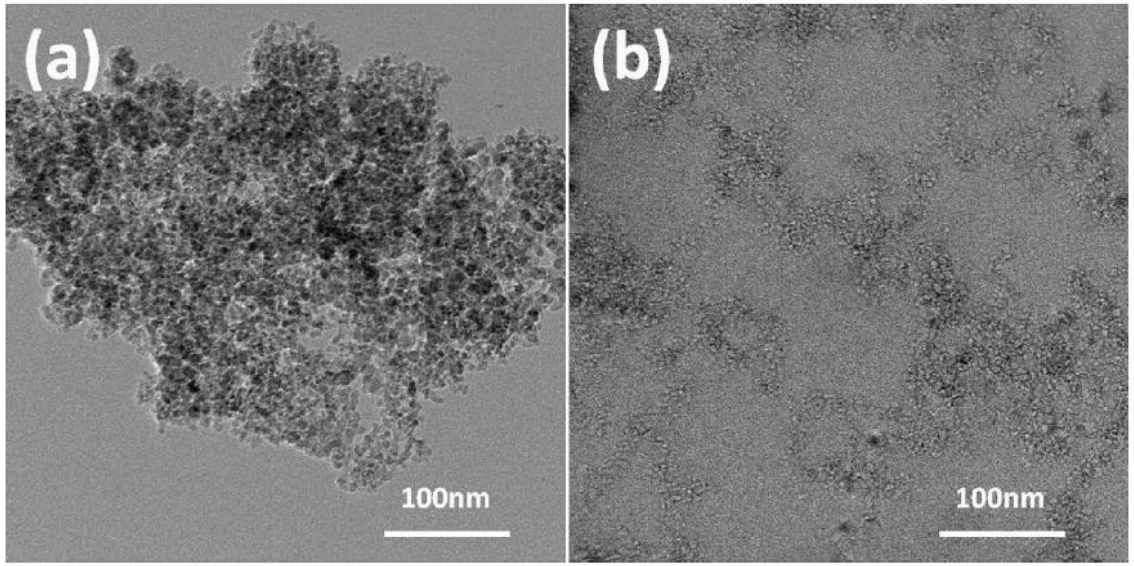
Morphological characterization

- **Scanning Electron Microscope, SEM**



Obtained from: J. Morales-Castillo, M. Apatiga, and V. Castaño, “Growth of diamond films from tequila", vol. 21, Jul. 2008.

- **Transmission Electron Microscope, TEM**



S. Zhao, J. Huang, X. Zhou, B. Ren, K. Tang, Y. Xi, L. Wang, L. Wang, and Y. Lu, “Highly dispersible diamond nanoparticles for pretreatment of diamond films on Si substrate", Applied Surface Science, vol. 434, pp. 260-264, 2018, issn: 0169-4332. doi: https : / / doi . org / 10 . 1016 / j . apsusc . 2017 . 10 . 145. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0169433217330969

Morphological Characterization

- **X-Ray Diffraction**

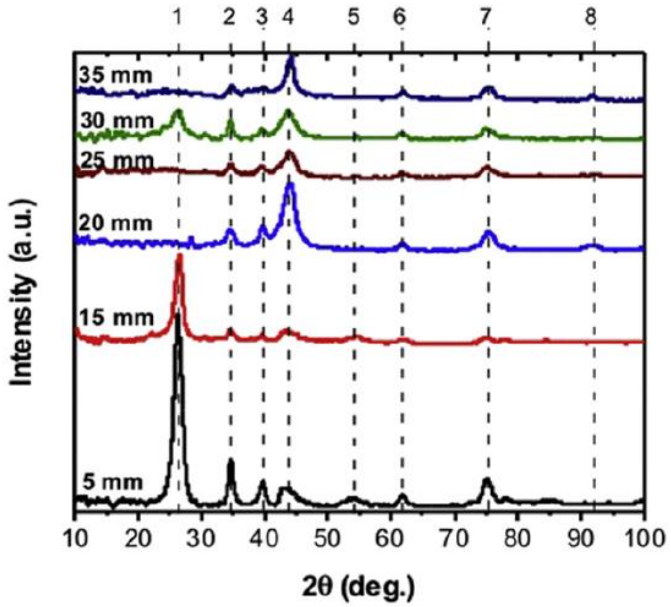


Fig. 6. XRD spectra from analysis of films grown at 5 mm, 15 mm, 20 mm, 25 mm, 30 mm and 35 mm filament-substrate distance at 450 °C heater temperature. The black and red spectra show the dominant graphite peak (1) and very small diamond peaks (4, 7, and 8) for the film grown at 5 and 15 mm filament-substrate distance. The blue, brown and violet spectra show the dominant diamond peaks (4, 7, and 8) characteristic of high quality UNCD films; the green spectra shows a balanced mixture of graphite and UNCD phases.

- **Atomic Force Microscope, AFM**

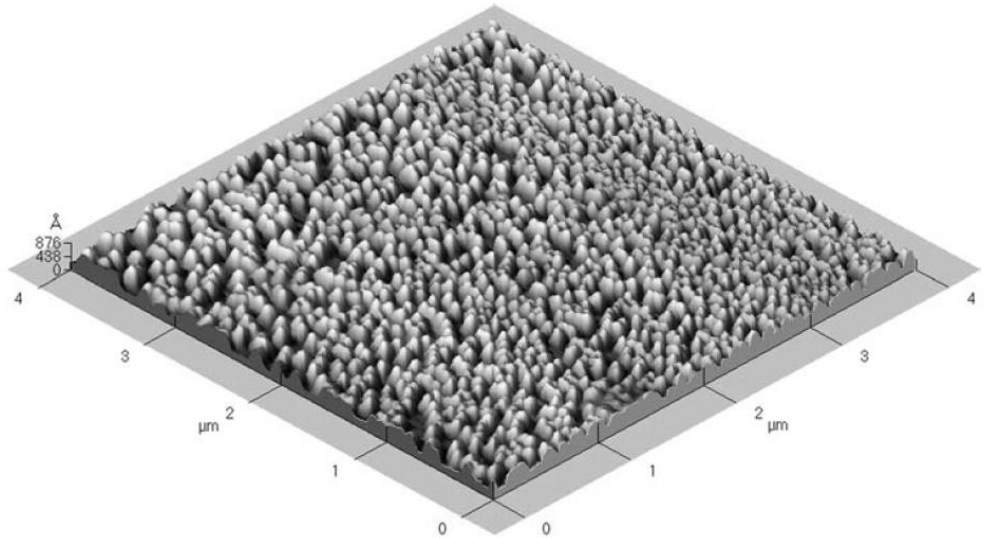


Figure 1. Atomic force microscopic image of a Tequila-derived PLICVD synthesised diamond film surface (taken from Morales *et al.*).

J. Alcantar-Peña, J. Montes, M. Arellano-Jimenez, J. O. Aguilar, D. Berman-Mendoza, R. García, M. Yacaman, O. Auciello, Low temperature hot filament chemical vapor deposition of ultrananocrystalline diamond films with tunable sheet resistance for electronic power devices, Diamond and Related Materials 69 (2016) 207 -213.

Characterization of optical properties and further uses

- Absorbance of UV
- Transmission of Visible light

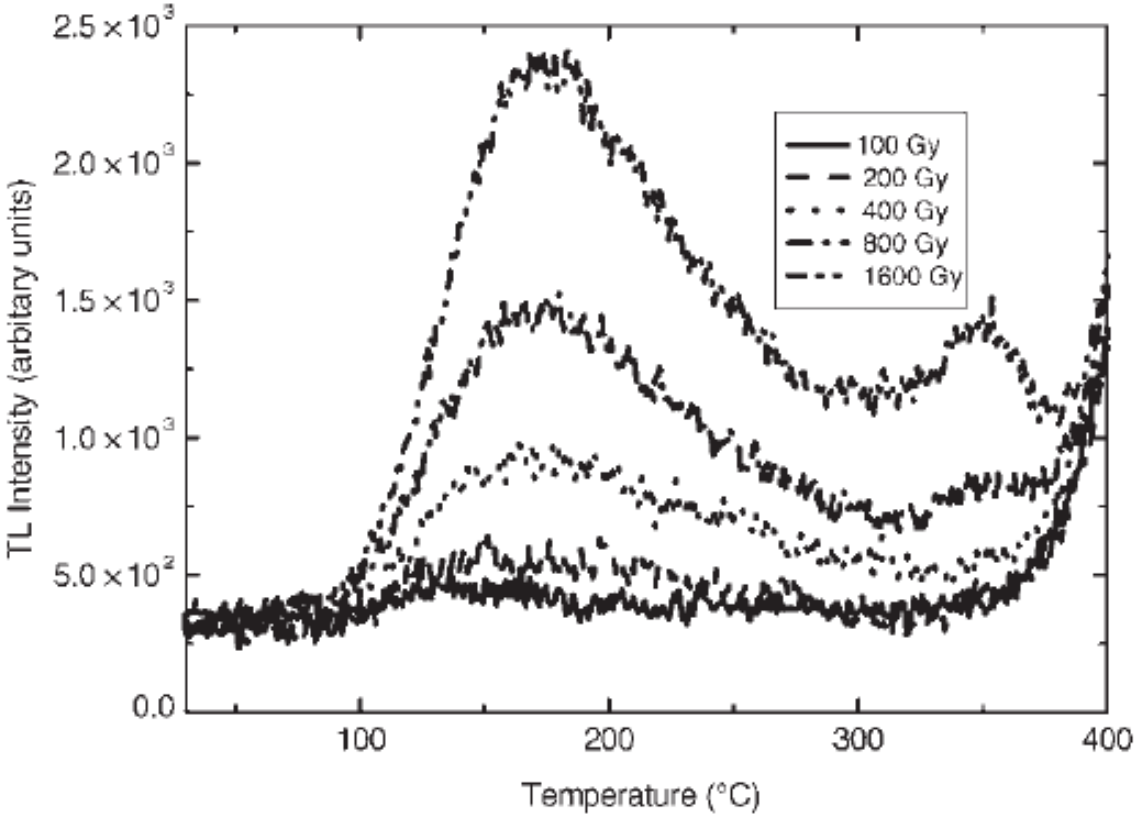


Figure 3. Characteristic glow curves of nano-diamond films growth using the PLICVD technique and Tequila as precursor, and after being exposed to beta particle irradiation in the dose range from 100 up to 1600 Gy (taken from Morales *et al.*).

Conclusions