Overview of Diamond Like Carbon (DLC) Coatings

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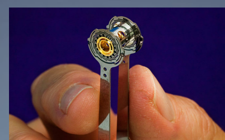
GENERAL ATOMICS

Motivation

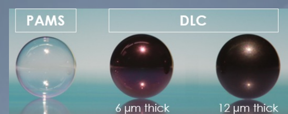
Opportunities against Current Ablator Materials

- Glow discharge polymer (GDP) capsules are amorphous; however, thicker coatings are required due to low density
- Diamond and Beryllium have coarse microstructure which leads to perturbations
- HDC (High-density Carbon) is hard to dope
- Thick DLC coating hard to grow



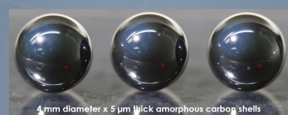
Why DLC?

- Amorphous, no grain boundaries
- High mechanical strength/hardness (stiffer than GDP)
- High density (between GDP and HDC)
- Many dopants possible
- Higher doping levels than HDC
- Carbon-based capsules



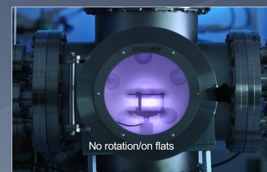
Goal

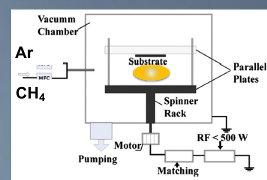
- High neutron yield gas balloons
- Large diameter, thin-walled (high aspect ratio)
- High burst strength and impermeable to gas
- Demonstrate doping
- DLC coatings on Plastic mandrels



Experimental Set-Up

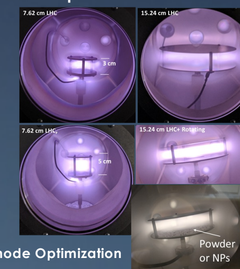
Linear Hollow Cathode RF Plasma Assisted Chemical Vapor Deposition





Diamond Like Carbon growth approach

- Several deposition techniques available
- RF-Plasma-assisted CVD is the most versatile
- Added Linear Hollow Cathode (increased plasma density) set-up
- Coat flats and shells
- Rotational setup for shells

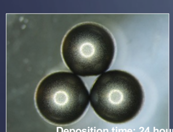


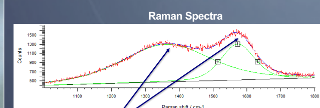
Hollow Cathode Optimization

Results, Discussion and Future Work

Coating

✓ *Achieved ~17µm thick uniform DLC coating on 2mm Si Mandrels*



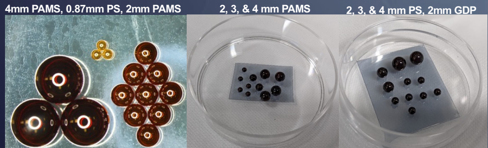


$I_D/I_G = 2.8$

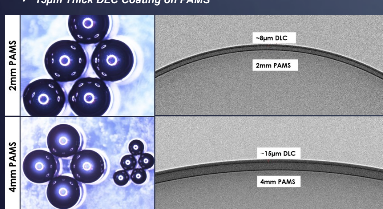
The I_D/I_G ratio is related to the amount of sp3 hybridization; the lower the ratio, the higher the amount of sp3 content, consequently, DLC coating with better tribological behavior

✓ *Transition to coating on plastic mandrels*

4mm PAMS, 0.87mm PS, 2mm PAMS | 2, 3, & 4 mm PAMS | 2, 3, & 4 mm PS, 2mm GDP

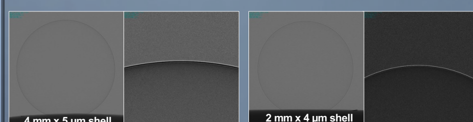


✓ *15µm Thick DLC Coating on PAMS*

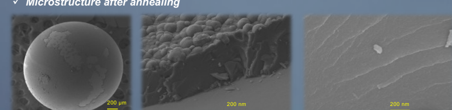


Pyrolysis and Leak Test

✓ *Successfully pyro'd PAMS from interior of the DLC shell*
✓ *Post-Pyro radiography & free-standing shells*

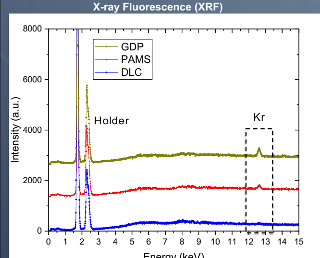


✓ *Microstructure after annealing*



✓ *Permeation (half-life) of DLC on PAMS is good*

X-ray Fluorescence (XRF)



DD Half-life

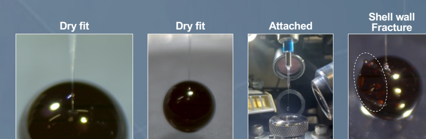
Capsule Identity	Half-life (hours)
PAMS 2mm	Below Detection
PAMS 3mm	0.14
PAMS 4mm	0.27
GDP 2mm	Below Detection
DLC-95 2mm	19.17
DLC-95 3mm	23.67
DLC-95 4mm	16.39

- Kr leak test: DLC on PAMS is almost gas tight
- DD leak test: Half life ~ 20 hours

Burst Test and Free-Standing High Aspect Ratio DLC Capsules

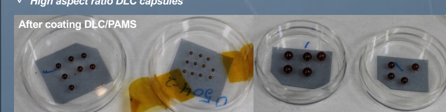
✓ *Mechanical Strength Evaluation*

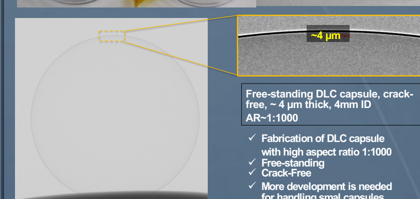
Constructed a thin wall capsule fill tube assembly for leak, burst, & buckle testing 2mm shell, ~4µm wall thickness, DLC-78



- CFTA attachment was successful on the 2mm free-standing DLC shells
- The thin shell fractured under UV light when curing the glue
  - DLC material absorbs UV light and gets hot
  - Lower UV intensity or the distance increased
  - Alternative curing method or glues may be needed (uniform low temp. cure)

✓ *High aspect ratio DLC capsules*



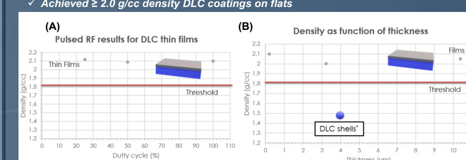


Free-standing DLC capsule, crack-free, ~ 4 µm thick, 4mm ID AR~1:1000

- ✓ Fabrication of DLC capsule with high aspect ratio 1:1000
- ✓ Free-standing
- ✓ Crack-Free
- ✓ More development is needed for handling smal capsules

DLC Density and future work

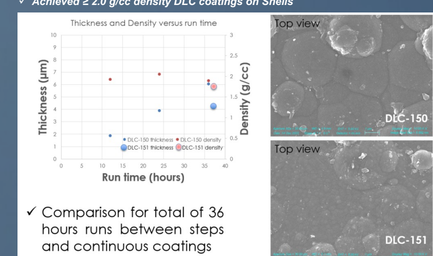
✓ *Achieved ≥ 2.0 g/cc density DLC coatings on flats*



- DLC thin films thickness on Si flats ~200nm
- Pulsed RF at 100Hz, 25W and 30mtorr
- No rotation

- Continuous RF (100% duty cycle), 25W and 30mtorr
- No rotation

✓ *Achieved ≥ 2.0 g/cc density DLC coatings on Shells*



✓ Comparison for total of 36 hours runs between steps and continuous coatings

Future work

Significant advancements have been made in this area. However, several technical challenges remain

1. Thick coatings (above 50 µm)
2. Heat treatments and new hydrocarbon gas to improve density
3. Laser drilling challenges
4. Improve surface finish by polishing

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