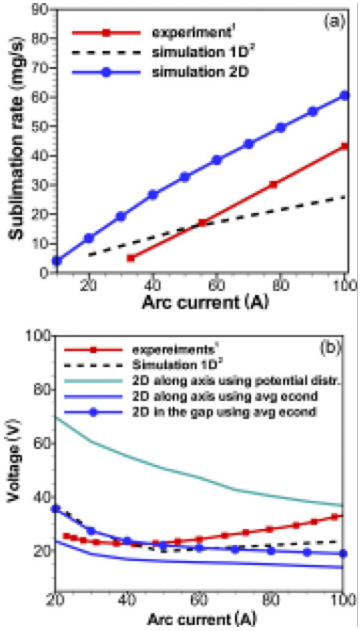
Project GWU # 2

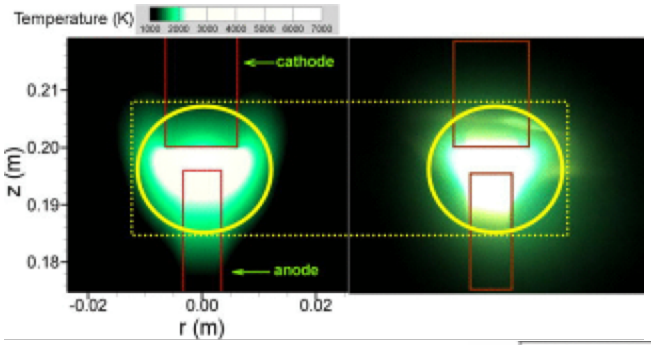
- **Title:** Plasma Simulation Validation
- **PI(s):** Michael Keidar and Carles Corbella, George Washington University
- **Need and Relevance:** validation of new codes for high-pressure plasma processing, nanoparticle synthesis
- **Goals:** to develop plasma diagnostics for code validations
- **Approach:** develop new diagnostics, hypothesis and validation
- **Outcomes/Deliverables:** diagnostics, code validation
- **Project Duration, Budget:** 2 years / $50k/year

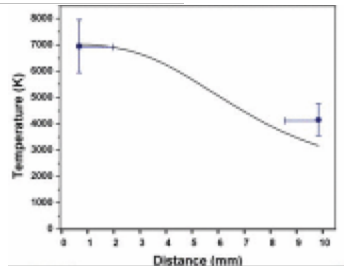
Need and Relevance

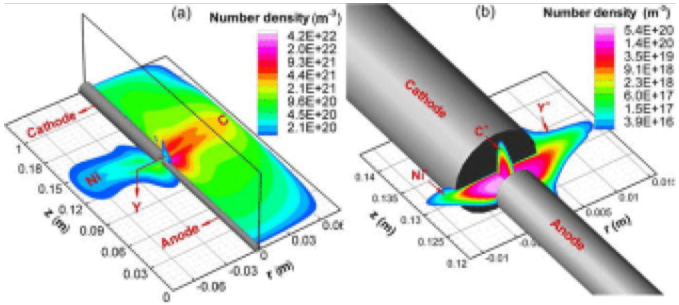
Atmospheric arc discharge for nanoparticle synthesis

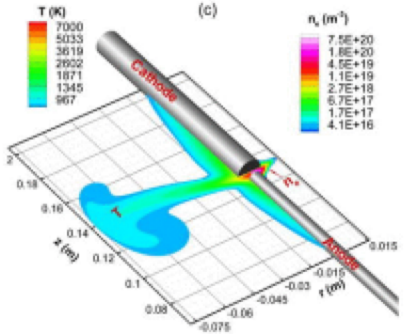
Numerical simulations need to be validated









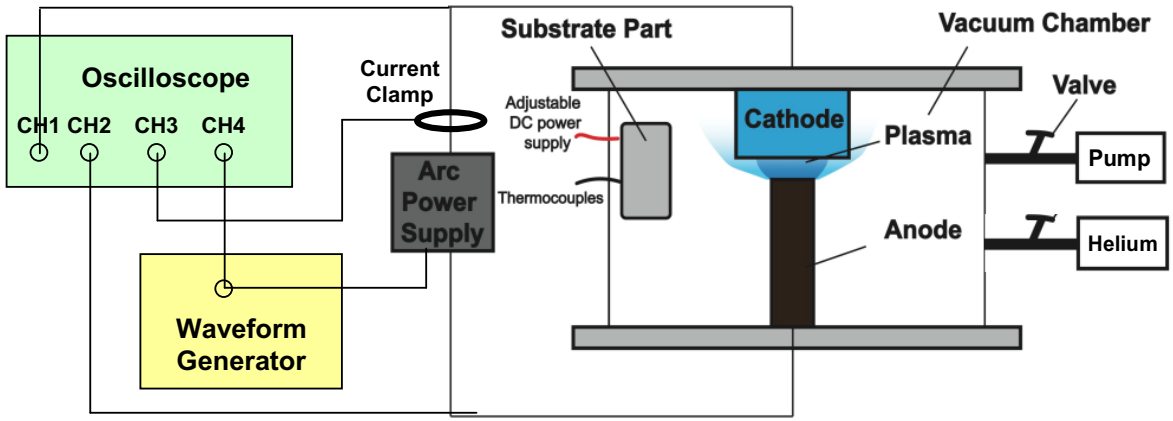


Goals

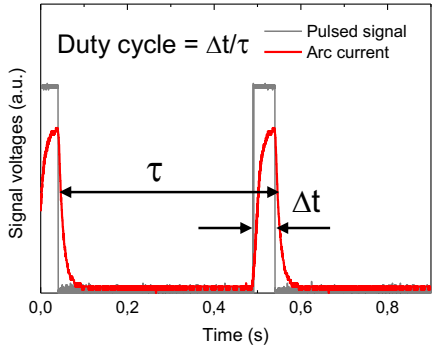
1. Experimental **validation** of plasma simulation codes
2. Design of **controllable** arc processes to synthesize 2-D materials (graphene, MoS_2, h-BN)
3. Investigation of arc **plasma parameters**

Approach

Deposition setup: anodic arc discharge of graphite and molybdenum



Pulsed signal (1-5 Hz)
10% duty cycle
300 Torr He



Approach

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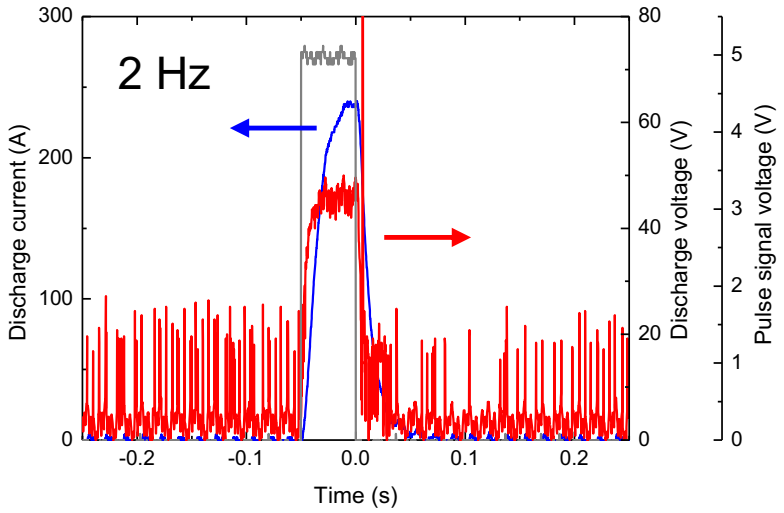
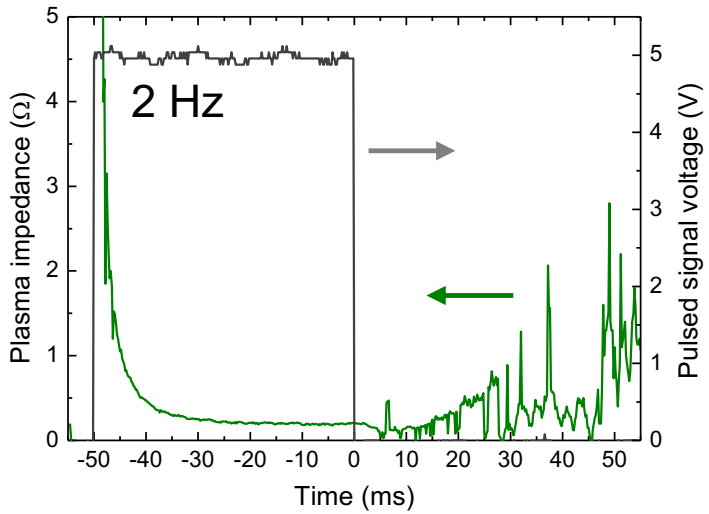




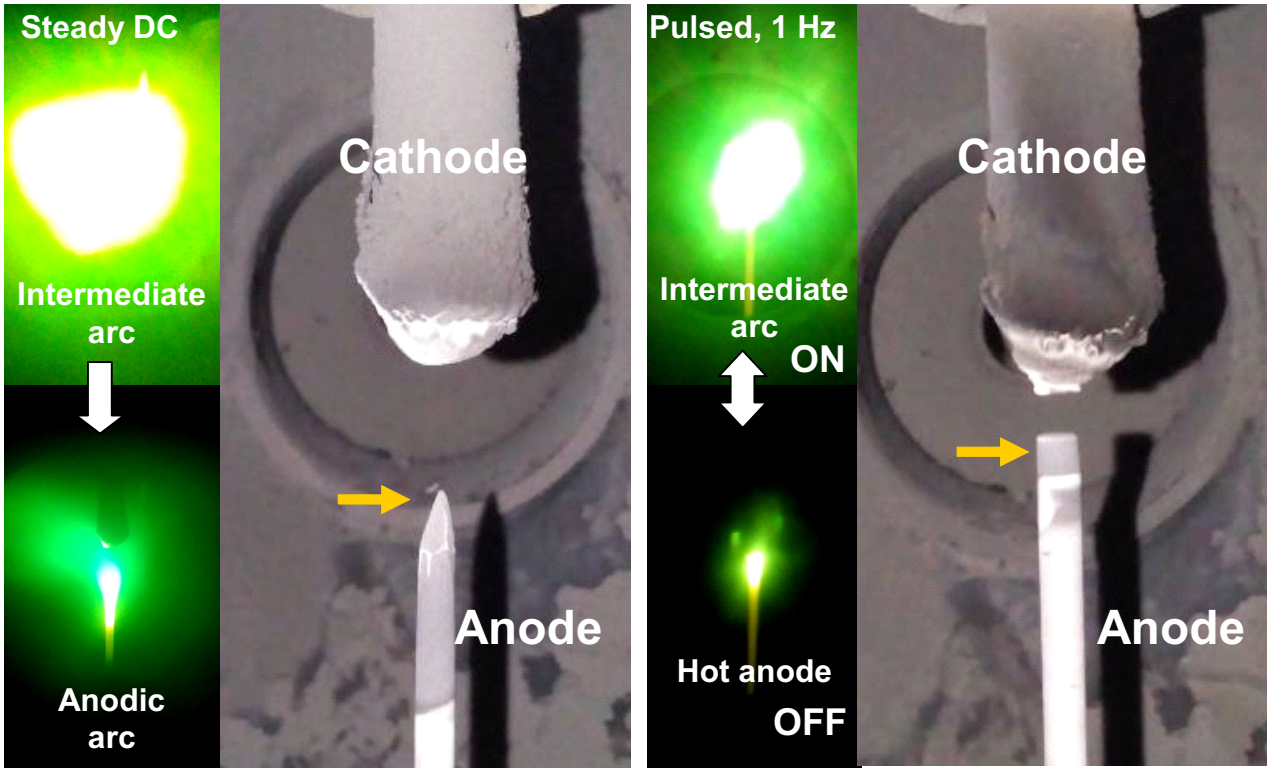
Outcomes/Deliverables

Erosion dynamics of carbon arc discharge

Frequency (Hz)	Peak arc current (A)	Peak arc voltage (V)	Average power (kW)	Ablation rate (mg/s)	Rate per pulse (mg/s)	Efficiency (g/Kwh)	Min R (Ohm)
DC	60	35	2.1	2.1	2.1	3.5	0.6
DC	150	65	10	22	22	8	0.4
1	250	50	1.0	1.0	10	4	0.2
2	250	50	1.1	1.0	10	3.3	0.2
5	180	50	0.9	0.8	8	3.4	0.2

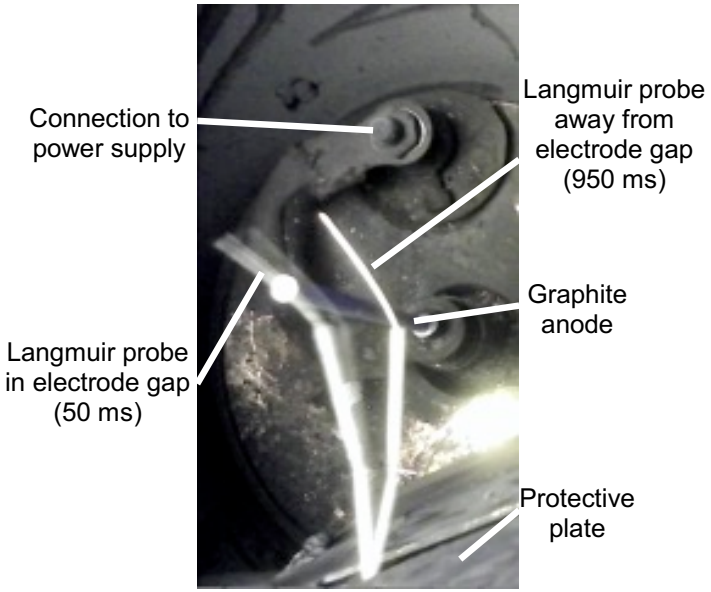
Outcomes/Deliverables

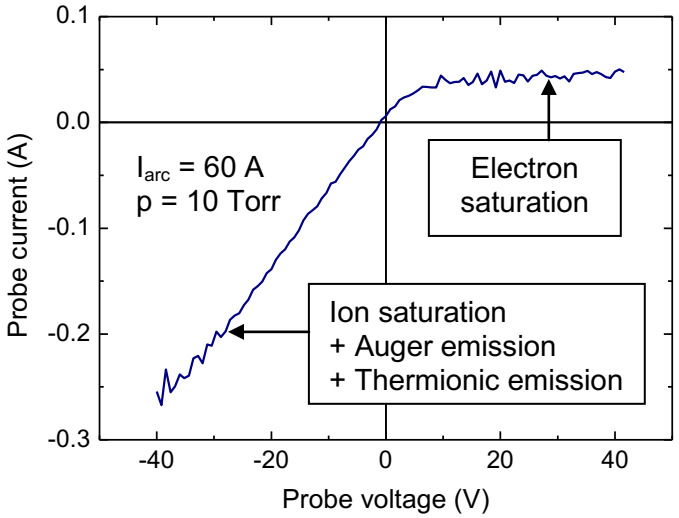
Optical emission pattern and ablation modes



Approach

Plasma diagnostics: Fast Langmuir probe





Fast LP

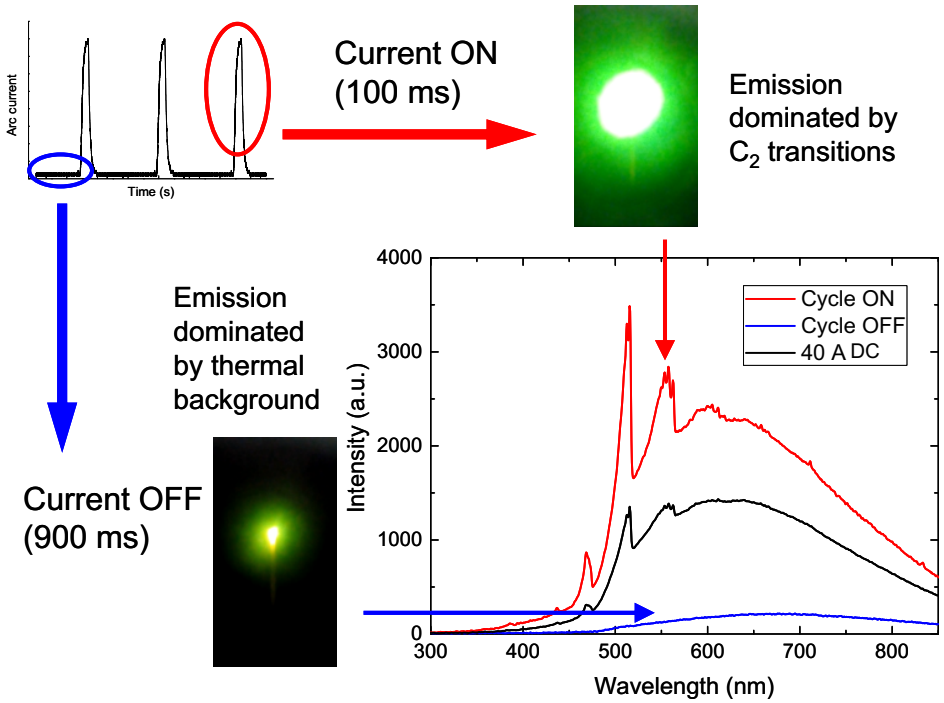
$n_e = 10^{16}$-10^{17} m^{-3}

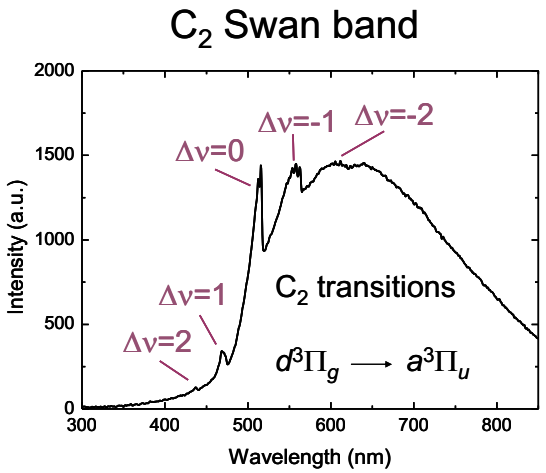
T_e = 0.5-2.0 eV

Strong electron emissions by Auger and thermionic processes

Outcomes/Deliverables

Plasma diagnostics: optical emission spectroscopy





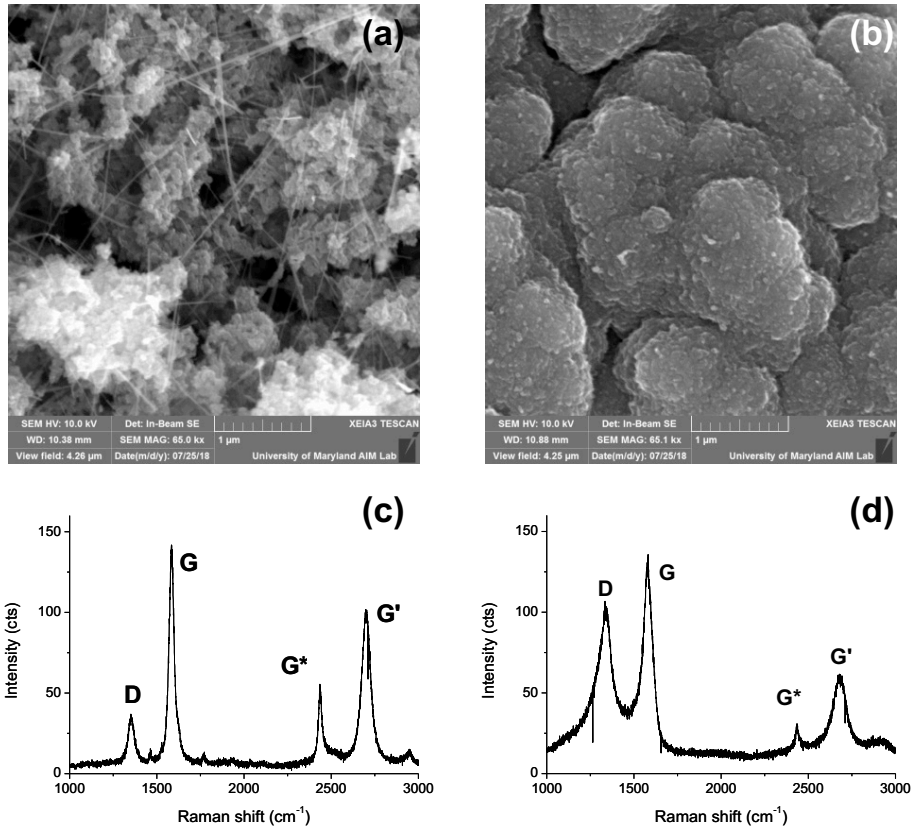
OES

$T_{vib} \approx 0.7$ eV

Outcomes/Deliverables

Sample characterization

SEM and Raman spectroscopy: carbon nanotubes and graphene network



"Pulsed anodic arc discharge for the synthesis of carbon nanomaterials", submitted to PSST

Project Timeline and Duration

Task / month	1	2	3	4	5	6	7	8	9	10	11	12
Experiments with pulsed arc	x	x	x	x								
Plasma parameters measurements (Langmuir probe)				x	x	x	x					
Optical diagnostics							x	x	x	x		
TechX Code validation for various electrode materials									x	x	x	x

Project Budget

Item	Cost
Post-doc support	$ 35,000.00
Supplies	$ 7,000.00
Purchased services	$ 0.00
Equipment	$ 0.00
Travel	$ 3,000.00
Project total*	**$ 45,000**